DOCUMENT RESUME

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IDENTIFIERS	Military Curriculum Project

ABSTRACT

This plan of instruction, lesson plans, student handouts, and programed texts for a secondary-postsecondary level course in engine mechanics is one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. It is the first of a four-part course (see Note for other sections) covering general vehicle mechanics, including inspection, maintenance, and repair. The plan of instruction suggests number of hours of class time devoted to each lesson in two blocks of instruction (Blocks I and II), a total of sixty-nine hours of instruction: (1) Publications (2 lessons, 12 hours), including basic math and hand, special, and measuring tools and (2) engines (8 lessons, 57 hours), including engine assembly, servicing, and reassembly; cooling, lubrication, and crankcase ventilating systems; soldering; corrosion control; emission control system; carburetors; governors; and fuel system. It also details criterion objectives and support materials needed. Lesson plans outline teaching steps. Student materials in Block I include two handouts and seven programed texts and in Block II a study guide, workbook, worksheet, and three programed texts. Military manuals, commercial texts, and audiovisuals are suggested, but not provided. (YLB)

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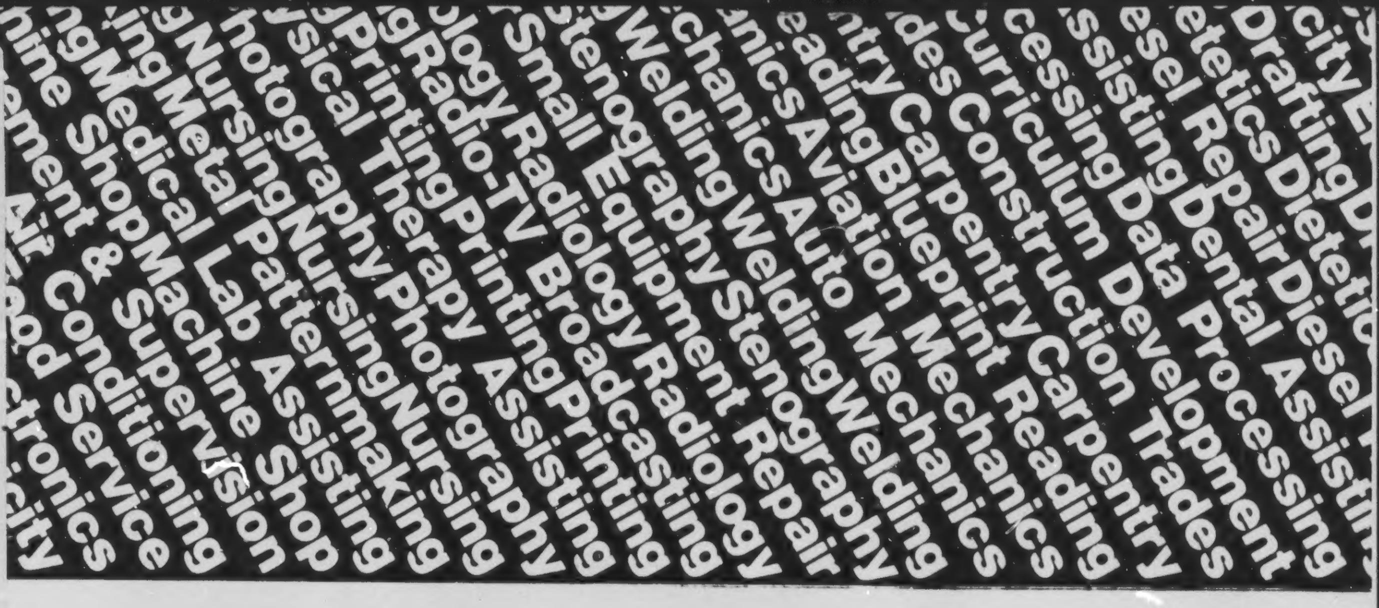
Drafting
Dietetics Dietetic
Diesel Repair Diesel
Dental Assisting
Data Processing
Curriculum Development
Construction Trades
Carpentry Carpentry
Blueprint Reading
Aviation Mechanics
Auto Mechanics
Welding Welding
Stenography Stenography
Welding
Small Equipment Repair
Radiology Radiology
Radio-TV Broadcasting
Printing Printing
Physical Therapy Assisting
Photography Photography
Nursing Nursing
Patternmaking
Metal Lab Assisting
Medical Machine Shop
Machine Shop Supervision
Air Conditioning
Food Service
Electronics
Electricity

Military Curricula for Vocational & Technical Education

GENERAL PURPOSE

VEHICLE MECHANIC

BLOCKS I AND II

8-9

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

CE 024 828

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY

This military technical training course has been selected and adapted by The Center for Vocational Education for "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education," a project sponsored by the Bureau of Occupational and Adult Education, U.S. Department of Health, Education, and Welfare.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION
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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

MIDWEST
Robert Patton
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1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

NORTHEAST
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Mississippi State, MS 39762
601/325-2510

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

GENERAL PURPOSE VEHICLE MECHANIC, BLOCKS I AND II

Table of Contents

Course Description — Page 1

Plan of Instruction — Page 3

Block I - Publications

- Lesson Plans — Page 16
- Automotive Terminology - Handout — Page 23
- Glossary of Mechanical Terms - Handout — Page 30
- Fire Safety - Programmed Text — Page 44
- Shop Safety - Programmed Text — Page 68
- Basic Mathematics - Programmed Text — Page 106
- Automotive Terminology and Hardware - Programmed Text — Page 124
- Mechanic's Handtools - Programmed Text — Page 154
- Special Tools - Programmed Text — Page 188
- Measuring Devices - Programmed Text — Page 221

Block II - Engines

- Lesson Plans — Page 247
- Engines - Study Guide — Page 276
- Engines - Workbook — Page 378
- Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation and Valve Adjustment - Worksheet — Page 443
- Soldering, Tube Cutting, Bending, and Flaring - Programmed Text — Page 452
- Vehicle Storage, Climatic Techniques and Corrosion Control - Programmed Text — Page 463
- The Typical Vehicle Fuel System - Programmed Text — Page 498

GENERAL PURPOSE VEHICLE MECHANIC, BLOCKS I & II

Classroom Course

Developed by:
United States Air Force

Development and Review Dates
November 6, 1975

D.O.T. No.:
620.281

Occupational Area:
Engine Mechanics

Target Audiences:
Grades 11-adult

Print Pages:
498

Cost:
$10.00

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials:	Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Instructional Design:	Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Type of Instruction:	Group Instruction:	Individualized:	
				No. of pages												
Block I – *Publications*		●	●		●		*		●					●	●	
Block II – *Engines*		●		75		●	*		●			*		●		

* Materials are recommended but not provided.

THE CENTER FOR VOCATIONAL EDUCATION

Expires July 1, 1978

Course Description:

This section is the first of a four-part course covering general vehicle mechanics. The entire course covers inspecting, servicing, testing, adjusting, troubleshooting, and repairing automotive general purpose vehicles; gasoline engine tune-up and repair; manual and automatic transmission replacement and adjustment; lubrication system servicing and repair; cooling system servicing; power train repair; front end and steering system adjustment and repair; brake system adjustment and repair; warning and lighting system repair; hydraulic control repair; air conditioning system servicing; corrosion control; and preparation of vehicles for climatic conditions and shipment. This section of the course contains two blocks of instruction covering 69 hours.

Block I — *Publications* consists of two lessons covering 12 hours of instruction. Three lessons were deleted because they discuss military forms and organization. The lesson topics and respective hours follow:

Basic Math (6 hours)
Hand, Special and Measuring Tools (6 hours)

Block II — *Engines* contains eight lessons covering 57 hours of instruction.

Principles of Internal Combustion Engines and Engine Disassembly (6 hours)
Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation and Valve Adjustment (18 hours)
Principles, Inspection, and Repair of Cooling, Lubrication, and Crankcase Ventilating Systems, and the Use of Valve Reconditioning Equipment (6 hours)
Basic Soldering, Cutting, Bending, and Flaring Copper Tubing (4 hours)
Climatic Techniques, Corrosion Control, and Storage (2 hours)
Gasoline Engine Fuel System Units and Emission Control Systems (6 hours)
Construction and Operating Principles of Carburetors and Governors (7.5 hours)
Service, Repair, and Adjustment of Carburetors and Governors (7.5 hours)

This section contains both teacher and student materials. Printed instructor materials include lesson plans outlining the teaching steps and a plan of instruction detailing units of instruction, criterion objectives, duration of the lessons, and support materials needed. Student materials include three handouts: *Automotive Terminology, A Glossary of Mechanical Terms,* and *A Bibliography*. Eight programmed texts on fire safety, shop safety, basic mathematics, automotive terminology and hardware, mechanics' handtools, special tools, and measuring devices are also provided. The programmed texts provide frame by frame instruction for individualized study.

Several military manuals and commercially produced texts are referenced, but are not provided. Audiovisuals suggested for use with the entire course include 53 transparencies, 10 films and 205 slides. This section used in conjunction with the remaining three sections provides comprehensive coverage of vehicle inspection, maintenance and repair. Some documents can be used individually as sub-units, remedial, or individualized study, and the entire course can be used in a group instructional setting or adapted for individual use.

3

POI 3ABR47~~330~~ 332

(PDS Code AD5)

PLAN OF INSTRUCTION

(Technical Training)

GENERAL PURPOSE VEHICLE ~~REPAIRMAN~~ Mechanic

8-9

AIR TRAINING COMMAND

CHANUTE TECHNICAL TRAINING CENTER

2 January 1975 - Effective 2 January 1975 with Class 750102

POI 3ABR47330

LIST OF CURRENT PAGES

This POI consists of 61 current pages issued as follows:

Page No.	Issue
Title	Original
A	Original
i	Original
ii	Original
1 thru 52	Original
A1-1 thru A1-5 . .	Original

DISTRIBUTION: ATC/TTMS-1, AULD-1, TWS-100, TTOC-3, TTOT-1, TTOXW-1, TTOR-1, TTE-1, CCAF/AY-2

PLAN OF INSTRUCTION	COURSE TITLE General Purpose Vehicle Repairman - Part I

BLOCK TITLE
Publications

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
1. ~~Orientation~~, Basic Math, ~~and Security~~	6 Day 1	

1. ~~Orientation~~, Basic Math, ~~and Security~~

a. Orientation

(1) School orientation conducted in accordance with SR 50-18, Atch 3 outline.

~~b. Without reference, identify basic facts and terms relating to career progression in vehicle maintenance with 70% accuracy.~~

~~c. Without reference, identify examples of security information as being classified, unclassified, or of possible intelligence value with one hundred percent accuracy.~~

~~d. Without reference, identify examples of security information as being top secret, secret, confidential, or for official use only with one hundred percent accuracy.~~

~~e. Without reference, select the most secure mode of transmitting classified information. No error is permitted.~~

~~f. Without reference, identify security procedures involved in voice communications. No errors are permitted.~~

g. Without reference, identify basic facts and procedures concerning automotive personnel and equipment shop safety. Seventy-five percent of the facts and procedures must be identified correctly.

Column 1 Reference	STS Reference
1a(1)	None
1b	1
1c	2a
1d	2b
1e	2c
1f	2d
1g	3

Audio Visual Aids
35mm Slide Set NSC-001
CCAF
Chart: Vehicle Maintenance Career Field

Instructional Materials
3ABR47330-HO-100, Bibliography
3ABR47330-HO-101, Automotive Terminology
3ABR47330-HO-101A, Glossary of Mechanical Terms
~~ATGPT 52-11, Study Skills~~
CISDT-PT-47-1, Fire Safety
3ABR47330-PT-101B, Shop Safety
~~3ABR47330-PT-101C, Security~~
3ABR47330-PT-101E, Basic Math
~~3ABR47330-PT-101F, Career Field Progression~~
3ABR47330-PT-107B, Automotive Terminology and Hardware

Training Methods
Discussion/Demonstration (1 hr)
Self-Instruction (5 hrs)

Instructional Environment/Design
Classroom (6 hrs)
Group/Lock Step (NOTE: Group/Lock Step is applicable to all of Blocks I through VII.)

Instructional Guidance
Use PTs and necessary review of subjects to accomplish instruction. Use Atch 3 to SR 50-18 as a guide for orientation. Stress energy and material conservation.

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. I	PAGE NO. 1

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
✓ 2. Hand, Special, and Measuring Tools a. Given pictures of vehicle maintenance hand, special, and measuring tools, identify the name and/or function of each. Eighty percent of the name and/or function must be identified correctly.	6 Day 2	**Column 1 Reference** 2a — **STS Reference** 9 **Instructional Materials** 3ABR47330-PT-102B, Mechanic's Handtools 3ABR47330-PT-103C, Special Tools 3ABR47330-PT-104B, Measuring Devices **Audio Visual Aids** Film: FTA 496A, Torquing Equipment and Usage **Training Equipment** Trainers: 61-2825, Handtool Display (10) 60-2558, Mandrel Measure (1) 60-2521, Measure Block Steel Rule (10) **Training Methods** Self-Instruction (6 hrs) **Instructional Environment/Design** Classroom (6 hrs) **Instructional Guidance** Use PTs and necessary review of subjects to accomplish instruction.
✓ ~~3. Air Force Technical Orders and Commercial Publications~~ ~~a. Without reference, identify basic facts relating to the scope and application of administrative publications. Seventy percent of the facts must be identified correctly.~~ ~~b. Without reference, identify the relationship of basic facts concerning the scope and application of the Technical Order~~	9 Day 3, 4 (1.2)	~~**Column 1 Reference** — **STS Reference**~~ ~~3a — 4a~~ ~~3b — 4b~~ ~~3c — 4c~~ ~~3d — 4d~~ ~~**Instructional Materials**~~ ~~3ABR47330-PT-103, Air Force Technical Order System~~ ~~3ABR47330-WB-105, Air Force Technical Order System and Commercial Publications~~ ~~TO 00-20B-5, Vehicle and Base Support and Maintenance System and Records Administration~~ ~~TO Training File~~

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. I	PAGE NO. 2

ATC FORM 337A MAR 73 PREVIOUS EDITIONS OBSOLETE. U.S. GPO: 1973-775-403/129 (Final Copy ½ - 8 X 10½) (Final reduction may include area above this line)

MODIFICATIONS

Pages 3-4 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

8

PLAN OF INSTRUCTION	COURSE TITLE General Purpose Vehicle Repairman - Part I

BLOCK TITLE

Engines

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
1. Principles of Internal Combustion Engines and Engine Disassembly a. Without references, identify basic facts, principles of operation, function, and relationship of engine system and components with 70% accuracy.	6 Day 6	Column 1 Reference 1a — STS Reference 11a Instructional Materials 3ABR47330-SG-201, Principles of Internal Combustion Engines and Engine Disassembly 3ABR47330-WB-202, Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation, and Valve Adjustment 3ABR47330-WB-202A, Engines Audio Visual Aids ~~Film: FO 23-55A, Where Mileage Begins~~ Training Equipment Trainers: 60-2759, Engine Assembly IHC 6 Cyl (2) 66-3299, Engine Cutaway (10) 60-2584, Four Stroke Cycle Principles (10) Mechanic's Common Handtools (1) Training Methods Discussion/Demonstration (4 hrs) Performance (2 hrs) Instructional Environment/Design Classroom (4 hrs) Laboratory (2 hrs) Instructional Guidance Discuss publications, handtools, special tools, and engine principles. Assign two students to one engine trainer and supervise them closely while they drain the oil and coolant, partially disassemble the engine, and place components on display boards. Point out errors and correct them on the spot. Stress energy and material conservation.

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. II	PAGE NO. 5

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION HOURS	3 SUPPORT MATERIALS AND GUIDANCE
2. Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation, and Valve Adjustment	18 Day 7,8,9	Column 1 Reference — STS Reference 2a — 3, 9, 11b 2b, 2c — 3, 9, 11c 2d — 3, 9, 11d
a. Given an engine trainer and tools, practicing all safety precautions, disassemble an engine following all the procedures outlined in the student workbook.	(2)	Instructional Materials 3ABR47330-SG-202, Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation, and Valve Adjustment 3ABR47330-WB-202, Engine Disassembly, Engine Components, and Parts Servicing, Engine Reassembly, Operation, and Valve Adjustment 3ABR47330-WB-202A, Engines
b. Given engine trainer and components, tools, equipment, and workbook, practicing all safety precautions, inspect, repair, and/or service engine components IAW procedures and specifications in student workbook with instructor guidance as required on more difficult tasks.	(6)	Audio Visual Aids Film: TV 77-661, Distributor Installation and Timing Charts - Engine Components
c. Given engine trainer, tools, and practicing all safety precautions, reassemble engine trainer following all the procedures outlined in student workbook.	(4)	Training Equipment Trainer: 60-2759, Engine Assembly IHC 6 Cyl (2) Mechanic's Common Handtools (1) Measuring Devices and Special Tools (1) Spring Testers (5) Timing Lights (2)
d. Given engine trainer, workbook, tools and equipment, practicing automotive personnel and equipment shop safety, use visual, auditory, operational means, and test equipment to check and adjust engine mechanical systems IAW procedures outlined in student workbook.	(6)	Vacuum Pressure Gauge (2) Engine Tachometer (2) Compression Gauge (2) Rod Alignment Tester (5) Bench Items: Miscellaneous Engine Components
		Training Methods Discussion/Demonstration (6 hrs) Performance (12 hrs) Instructional Environment/Design Classroom (6 hrs) Laboratory (12 hrs) Instructional Guidance Discuss parts, servicing, reconditioning procedures, and techniques, and proper use of publications. Include servicing and reconditioning of

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. II	PAGE NO. 6

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE

engine components, final assembly of engine trainers and inspections, adjustment, minor tune-up and perform compression test. Complete training objectives using workbook and applicable publications. Point out and correct errors on the spot.

✓ 3. Principles, Inspection, and Repair of Cooling, Lubrication, and Crankcase Ventilating Systems, and the Use of Valve Reconditioning Equipment

6
Day 10

a. Without references, identify basic facts and terms relative to the principles, function, and relationship of cooling, lubricating, and crankcase ventilating systems with 70% accuracy.

b. Given engine trainer, tools, equipment, and practicing personnel and equipment shop safety, repair or service lubricating, cooling, and crankcase ventilating systems following procedures outlined in student study guide.

c. Given tools, equipment, engine trainer, practice personnel and equipment shop safety, repair or service valves and mechanisms IAW manufacturer's manual. Instructor assistance required on more difficult tasks.

Column 1 Reference	STS Reference
3a	11a
3b	11a
3c	3, 4d, 9, 11b, 11c

Instructional Materials
3ABR47330-SG-203, Principles, Inspection, and Repair of Cooling, Lubrication, and Crankcase Ventilating Systems, and the Use of Valve Reconditioning Equipment
Commercial Publication: Valve Refacer Instructions

Audio Visual Aids
Charts - Engine Systems

Training Equipment
Trainer: 60-2759, Engine Assembly IHC 6 Cyl (2)
Mechanic's Common Handtools (1)
Special Tools (1)
Measuring Tools and Devices (1)
Spring Testers (2)
Valve Reconditioning Equipment (5)
Thermostat Testers (10)
Pressure Cap Testers (5)
Back Flushing Equipment (5)
Bench Items: Miscellaneous Engine Components

Training Methods
Discussion/Demonstration (3 hrs)
Performance (3 hrs)

Instructional Environment/Design
Classroom (3 hrs)
Laboratory (3 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION HOURS	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Discuss parts servicing, reconditioning procedures and techniques; proper use of valve reconditioning equipment; and include servicing and reconditioning of engine components. Point out and correct errors on the spot.
4. Basic Soldering, Cutting, Bending, and Flaring Copper Tubing a. Given bench items, tools, equipment, practicing all safety precautions, bend and flare copper tubing, and perform soldering exercise IAW PT.	4 Day 11	**Column 1 Reference** 4a — **STS Reference** 9 **Instructional Materials** 3ABR47330-PT-204C, Soldering, Tube Cutting, Bending, and Flaring **Training Equipment** Mechanic's Common Handtools (1) Solder Equipment (1) Flaring Tools (1) Bench Items: Copper Tubing Fittings and Connections Electrical Wiring and Terminals **Training Methods** Self-Instruction (1 hr) Performance (3 hrs) **Instructional Environment/Design** Classroom (1 hr) Laboratory (3 hrs) **Instructional Guidance** Accomplish instruction using programmed text. Observe safety precautions while performing soldering tasks in the lab.

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
5. Climatic Techniques, Corrosion Control, and Storage a. Without reference, identify procedures for preparation of vehicles for winterization, storage, and shipment, and corrosion control with 70% accuracy.	2 Day 11	**Column 1 Reference** 5a — **STS Reference** 10a **Instructional Materials** 3ABR47330-PT-204D, Vehicle Storage, Climatic Techniques, and Corrosion Control **Training Methods** Self-Instruction (2 hrs) **Instructional Environment/Design** Classroom (2 hrs) **Instructional Guidance** Accomplish instruction using programmed text to complete lesson objectives.
6. Gasoline Engine Fuel System Units and Emission Control Systems a. Without reference, identify basic principles of operation, function, and relationship of fuel pumps, instruments, sending units, lines, fittings, filters, and manifold heat controls with 70% accuracy. b. Given TO, engine trainer, and tools, practice all safety precautions, and test fuel systems IAW TO. c. Without references, identify principles of operation, inspection, maintenance, and repair procedures of evaporative emission control systems with 70% accuracy.	6 Day 12	**Column 1 Reference** — **STS Reference** 6a — 15a 6b — 3, 4d, 9, 15c 6c — 10c **Instructional Materials** 3ABR47330-SG-206, Gasoline Engine Fuel Supply System Units 3ABR47330-PT-205B, The Typical Vehicle Fuel System TO 33D6-3-4-1, UDT **Audio Visual Aids** Charts - Fuel System Components Film: TF1-4045, Fuel Pump **Training Equipment** Trainer: 60-2759, Engine Assembly, IHC 6 Cyl (2) Mechanic's Common Handtools (1) Vacuum Pressure Gauge (2) Bench Items: Lines Fittings Filters Single-Action Fuel Pump (1)

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO II	PAGE NO 9

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION HOURS 2	SUPPORT MATERIALS AND GUIDANCE 3
7. Construction and Operating Principles of Carburetors and Governors a. Without references, identify basic facts and terms relative to the principles of operation, function, and relationship of carburetors and governors with 70% accuracy.	9 Day 13,14 (9)	**Training Methods** Discussion/Demonstration (3 hrs) Performance (3 hrs) **Instructional Environment/Design** Classroom (3 hrs) Laboratory (3 hrs) **Instructional Guidance** Discuss principles of operation, service, and/or repair, and checking of fuel system components such as fuel tanks, sending units, lines, filters, instruments, fuel pumps, and manifold heat control valves. Disassemble, repair, or service and reassemble components. Perform training using programmed text, bench items, and following safety rules. **Column 1 Reference** 7a **STS Reference** 15a **Instructional Materials** 3ABR47330-SG-207, Construction and Operating Principles of Carburetors and Governors TO 33D6-3-4-1 **Audio Visual Aids** Charts - Carburetor and Governors Film Strip: 70-8, Carburetors, Fundamentals, and Facts **Training Equipment** Trainers: 60-2760, Engine Continental, 4 Cyl (10) 60-2759, Engine Assembly, IHC 6 Cyl (2) Mechanic's Common Handtools (1) Vacuum Pressure Gauge (1) Tach-Dwell Tester (2) Bench Items: Carburetor (1) Governor (1)

PLAN OF INSTRUCTION NO. 3/ 3R47330	DATE 2 January 1975	BLOCK NO. II	PAGE NO. 10

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Methods Discussion/Demonstration (7 hrs) Performance (2 hrs) Instructional Environment/Design Classroom (7 hrs) Laboratory (2 hrs) Instructional Guidance Discuss carburetor and governor purpose, construction, and operating principles. Disassemble, inspect, and reassemble carburetors and governors. Complete training objectives using applicable manuals and safety precautions.
8. Service, Repair, and Adjustment of Carburetors and Governors	7.5 Day 14,15	Column 1 Reference — STS Reference 8a — 4d, 15b 8b — 3, 4d, 9, 15c
a. Given dyno trainer board, bench items, and tools, following all safety precautions, service and repair carburetors and governors, and troubleshoot carburetors and governor problems IAW study guide.	(3.5)	Instructional Materials 3ABR47330-SG-208, Service, Repair, and Adjustment of Carburetors and Governors TO 33D6-3-4-1 TO 33D6-3-10-1, Clayton Chassis Dynamometer
b. Given TO, engine trainer, tools, equipment, and practicing all safety precautions, use visual, auditory, operational means, and test equipment to check carburetors and governors IAW TO.	(4)	Audio Visual Aids Charts - Carburetor Adjustments Training Equipment Trainers: 60-2760, Engine Continental, 4 Cyl (10) 60-2759, Engine Assembly, IHC 6 Cyl (2) 61-2831, Dynamometer Inspection Record (10) Mechanic's Common Handtools (1) Special Tools (1) Vacuum Pressure Gauge (2) Tach-Dwell Tester (2) Bench Items: Carburetor (1) Governor (1)

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. II	PAGE NO. 11

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Methods Discussion/Demonstration (1.5 hrs) Performance (6 hrs) Instructional Environment/Design Classroom (1.5 hrs) Laboratory (6 hrs) Instructional Guidance Disassemble, inspect, service, repair, and reassemble carburetors and governors following safety practices. Record dynamometer readings, isolate malfunctions, and recommend corrective action. Diagnose hypothetical dynamometer test result problems. Complete training objectives using study references.
Related Training (identified in course chart).	20	
9. Measurement Test and Test Critique	1.5 Day 15	

PLAN OF INSTRUCTION NO. 3ABR47330	DATE 2 January 1975	BLOCK NO. II	PAGE NO. 12

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 15 Jan 75	INSTRUCTOR
COURSE NUMBER 3ABR~~47330~~ 47232	COURSE TITLE General Purpose Vehicle ~~Repairman~~ MEchANIC
BLOCK NUMBER I	BLOCK TITLE Publications

LESSON TITLE
Orientation, Basic Math and Security

LESSON DURATION

CLASSROOM /Laboratory	LABORATORY /Complementary	TOTAL
D&D 1 hr SI 5 hrs/None	None	6 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
1	2 January 1975	1

STS/CTS REFERENCE

NUMBER	DATE
STS473X0	3 Sep 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
None	None	None	1. 3ABR47330-HO-101 2. 3ABR47330-HO-101A 3. 3ABR47330-PT-101B 4. 3ABR47330-PT-101C 5. 3ABR47330-PT-101E 6. 3ABR47330-PT-101F 7. ATCP 52-11 8. 3ABR47330-HO-100

CRITERION OBJECTIVES AND TEACHING STEPS (OVER)

~~a. Orientation: (1) School orientation conducted IAW with SR 50-18, atch 3 outline.~~

~~b. Without reference identify basic facts and terms relating to career progression in vehicle maintenance with 70% accuracy.~~

~~c. Without reference, identify examples of security information as being classified, unclassified, or of possible intelligence value with one hundred percent accuracy.~~

~~d. Without reference, identify examples of security information as being top secret, secret, confidential, or for official use only with one hundred percent accuracy.~~

~~e. Without reference, select the most secure mode of transmitting classified information. No error is permitted.~~

~~f. Without reference, identify security procedures involved in voice communications. No errors are permitted.~~

ATC FORM AUG 72 770

☆ GPO: 1974 779-386/23

LESSON PLAN (Part I, General) CONTINUATION SHEET

CRITERION OBJECTIVES AND TEACHING STEPS (Continued)

g. Without reference, identify basic facts and procedures concerning automotive personnel and equipment shop safety. Seventy-five percent of the facts and procedures must be identified correctly.

Teaching Steps are Listed in Part II.

18

MODIFICATIONS

Pages 1-2 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

f. Administer preentry exam - record grade on master roster. This exam is given to project students knowledge on subjects covered in the course.

g. Administer the following programmed text:

(1) 3ABR47330-PT-101B, Shop Safety

~~(2) ATC PT 52-11, Study Skills~~

~~(3) 3ABR47330-PT-101F, Career Field Progression~~

~~(4) 3ABR47330-PT-101C, Security~~

(5) 3ABR47330-PT-101E, Basic Math

(6) CISDT PT 47-1 Fire Safety

These are lessons to be completed in the study area or as home assignment, time permitting. Tell the students they will be required to answer questions on an appraisal with 80% accuracy the following day.

h. Review PT instruction and objective with students. Be sure he knows what he is expected to do for each part. (From this point on the letters PT will be used in place of Programmed Text).

i. Make it clear to the students that an instructor will be available at all times to answer questions and provide assistance as needed.

j. Administer PTs 3ABR47330-PT-107B, Automotive Terminology and Hardware, 3ABR47330-HO-100 Bibliography, 3ABR47330-HO-101 Glossary of Mechanical Terms. These are for student information.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 15 Jan 75	INSTRUCTOR
COURSE NUMBER 3ABR~~47330~~ 47232	COURSE TITLE General Purpose Vehicle ~~Repairman~~ Mechanic
BLOCK NUMBER I	BLOCK TITLE Publications

LESSON TITLE
Hand, Special, and Measuring Tools

LESSON DURATION

CLASSROOM/Laboratory	LABORATORY/Complementary	TOTAL
SI 6 hrs/None	None	6 hrs

POI REFERENCE

PAGE NUMBER	PAGE DATE	PARAGRAPH
2	2 January 1975	2

STS/CTS REFERENCE

NUMBER	DATE
STS473X0	3 Sep 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 61-2825 2. Trainer: 60-2558 3. Trainer: 60-2521	None	None	1. 3ABR47330-PT-102B 2. 3ABR47330-PT-103C 3. 3ABR47330-PT-104B 4. Film: FTA 496-A

CRITERION OBJECTIVES AND TEACHING STEPS

a. Given pictures of vehicle maintenance hand, special and measuring tools, identify the name and/or function of each. Eighty percent of the name and/or function must be identified correctly.

Teaching Steps are Listed in Part II.

ATC FORM AUG 72 770

☆ GPO: 1973 779-396/23

Part II

INSTRUCTIONAL GUIDANCE

1. STUDY AREA INSTRUCTOR:

a. Have the following study materials and training equipment in the study area:

(1) 3ABR47330-PT-102B, Mechanic's Handtools

(2) 3ABR47330-PT-103C, Special Tools

(3) 3ABR47330-PT-104B, Measuring Devices

(4) Appraisal WS/Q/3ABR47330-101B-C-D-E-F-G

(5) 61-2825 Hand Tool Display

(6) 60-2558 Mandrel Measure

(7) 60-2521 Measure Block Steel Rule

(8) Film FTA 496A Torquing Equipment and Usage

b. Check PTs administered on previous day to insure student made all the required responses.

Remind students not to mark in instructional material

Conserve electricity, heat, etc.

c. Administer appraisal WS/Q/3ABR47330-101B-C-D-E-F-G. The student must satisfactorily answer questions on appraisal WS/Q/3ABR47330-101B-C-D-E-F-G with 80% accuracy.

d. In case of unsatisfactory completion of the lesson appraisal, the student will restudy PTs as needed.

e. After satisfactory completion of the lesson appraisal, administer 3ABR47330-PT-102B Mechanic's Handtools, 3ABR47330-PT-103C Special Tools, 3ABR47330-PT-104B Measuring Tools. These lessons are to be completed in the study area.

f. Review PT instruction and objective with students. Be sure he knows what he is expected to do for each part.

g. Show film FTA 496A Torquing Equipment and Usage. Quiz Film

h. Pass out tools to aid students with PT 3ABR47330-104B.

Trainers: 61-2825,
60-2558,
60-2521

(1) Micrometer

(2) Mandrel Measurement

MANDREL MEASUREMENTS

	#2	#3	#4
1.	.692	.952	1.196
2.	.734	.984	1.234
3.	.760	1.010	1.259
4.	.765	1.016	1.264
5.	.740	.986	1.241
6.	.746	.996	1.246
7.	.730	.980	1.230
8.	.775	1.024	1.275
9.	.769	1.006	1.268
10.	.755	1.006	1.256

i. As each student completes PTs, check to see that he made all the required responses.

j. After satisfactory completion of the PTs, administer appraisal WS/Q/3ABR47330-102A-B-C.

k. In case of unsatisfactory completion of PT appraisal, the student will restudy the parts as needed.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-HO-101
8 October 1970

AUTOMOTIVE TERMINOLOGY

This handout contains the definition and purpose of various types of vehicles and other terminology associated with vehicle maintenance. An understanding of this terminology will aid you throughout this school and, in your future job in the automotive maintenance field. These terms are not listed in alphabetical order, but are arranged in a sequence for easier learning.

Motor Vehicle - Any item of equipment mounted on wheels or tracks which derives motive power from a self-contained power unit, or is designed to be used in conjunction with such self-propelled equipment.

Commercial Design - A vehicle designed by the manufacturer as a production model for commercial sale and usage.

Military Design - A vehicle designed in accordance with military specifications to meet a specific requirement.

General Purpose Vehicle - A vehicle designed for moving personnel or material, and for towing trailers or semitrailers; a vehicle which will satisfy general automotive transport needs.

Special Purpose Vehicle - A vehicle designed for a special requirement; this includes specially designed items such as aircraft towing tractors, crash fire and rescue trucks, aircraft refueling vehicles, etc.

Materials Handling Equipment - A self-propelled vehicle designed to handle material. This includes forklifts, warehouse tractors, platform lift trucks, aircraft cargo loaders, etc.

Maintenance - All actions required to retain a vehicle/equipment in a serviceable condition or to restore it to a serviceable condition when material is economically repairable. The term "maintenance" includes inspections, testing, repair, overhaul, rebuilding, remanufacture, cannibalization and reclamation.

Organizational Maintenance - (Operator Maintenance). Maintenance that is the responsibility of, and performed by the using organization on its assigned equipment. This maintenance consists of daily cleaning, servicing and maintenance discrepancies.

Intermediate Maintenance - Maintenance that is normally the responsibility of, and performed by designated maintenance activities for direct support of using organizations. Its phases normally consist of calibrating, repairing or replacing damaged or unserviceable parts, components, or assemblies, modifying material, emergency manufacturing of unavailable parts, and providing technical assistance to using organizations.

OPR: TSDT
DISTRIBUTION: X
TSDT - 600; TSOC -2

Designed for ATC Course Use Only

Depot Maintenance - Maintenance that is the responsibility of, and performed by designated maintenance activities to augment stocks of serviceable material, and to support organizational and intermediate maintenance activities. This maintenance is accomplished by more extensive shop facilities and equipment and personnel of higher technical skill than are normally available at lower levels of maintenance.

Preventive Maintenance - The systematic inspection, detection, and correction of failures, either before they occur or before they develop into major defects to economically maintain equipment and facilities in a satisfactory and dependable operating condition.

Recurring Maintenance - Repetitive maintenance required as a result of incorrect diagnosis, poor workmanship, design deficiency, operator abuse and/or ineffective quality control, and material failure.

Scheduled Maintenance - Periodic prescribed inspection and/or servicing of equipment accomplished on a calendar, mileage or hours of operation basis.

Unscheduled Maintenance - Maintenance that is not scheduled but is required to correct deficiencies and restore vehicle/equipment to a serviceable condition.

Cannibalization - The authorized removal of a specific component or assembly from one item of equipment for installation on another to meet a priority. There is an obligation to replace the removed item.

Corrosion Control - That treatment required to prevent or correct corrosive action on vehicles/equipment.

End Item - A final combination of assemblies, component parts, and/or materials which are ready for their intended use.

Gross Vehicle Weight - Weight of a vehicle including fuel, lubricants, coolant, or vehicle material, cargo and operating personnel.

Limited Technical Inspection - An inspection performed to determine the current condition of a vehicle/equipment using DD Form 1361 and AFTO Form 91 when appropriate.

Periodic Inspection - An inspection accomplished at regular intervals of calendar time, miles or hours of operation.

Quality Control - Is the function of assuring that the quality of maintenance performed is of an acceptable degree and provides necessary serviceability and reliability most economically.

Reclamation - The dismantlement or disassembly of an end item for the purpose of converting serviceable components into the active inventory.

Vehicle Down for Maintenance - A vehicle placed in an out of commission status due to nonavailability of parts.

General Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-HO-100
13 November 1972

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As time permits, study the reference materials listed in the bibliography for the base library. After studying the materials listed, you will possess a much broader knowledge of the course than could be possible during normal classroom instruction.

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OPR: TWS
DISTRIBUTION: X
TWS - 250; TTOC - 2

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30

PREPARE THE MAN

HANDOUT

3ABR47232-HO-101A

Technical Training

General Purpose Vehicle Mechanic

GLOSSARY OF MECHANICAL TERMS

8-9

19 February 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

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31

GLOSSARY OF MECHANICAL TERMS

OBJECTIVE

Using this "Glossary of Mechanical Terms," the student will be able to define terms, identify individual parts and complete assemblies associated with vehicle maintenance and operation. The student will also be able to use proper nomenclature for correspondence and supply purposes.

INTRODUCTION

A thorough knowledge of automotive terms, conditions, parts, and assemblies is necessary for the technician to communicate with his associates, supply personnel, and anyone concerned with the solution to automotive problems. Little progress would be made in rebuilding or repairing a vehicle if no one understood each other. Therefore a Glossary of Terms is very useful to vehicle maintenance and support personnel.

INFORMATION

This glossary is arranged in alphabetical order to aid the student in finding the meaning to any term.

PROCEDURE

By referring to this glossary the student can find terms related to the areas for which information is desired.

Example: The word "horsepower" will be referred to under the letter "H". Any information on horsepower, such as continuous horsepower, intermittent horsepower, peak horsepower, etc., can be found under this section.

GLOSSARY

A

Absolute Pressure: Total or true pressure. Gage pressure plus atmospheric pressure.

Absolute Temperature: Temperature in degrees above absolute zero. Adding 460° to Fahrenheit temperature converts it to Fahrenheit absolute.

Acceleration: Rate of change of speed. If a truck reaches a speed of 50 mph in 10 seconds from a standing start, its acceleration is 50/10 or 5 mph per second.

Air Cleaner: Filter for removing unwanted solid impurities from intake air.

Air-Fuel Ratio: Ratio of the weight of air to the weight of fuel supplied for combustion.

Supersedes 2ASR47250-HO-101, 3ABR47330-HO-101A, 5 May 1972.
OPR: TWS
DISTRIBUTION: X
TWS - 400; TTVGC - 1

50

Air Starting Valve: A valve which admits compressed air to an engine cylinder for starting purposes. Air starting valves remain closed or inoperative after the engine is started.

Alignment: Act or state of being in a straight or true line.

Alloy: Mixture of two or more different metals. Most common metals, such as iron and aluminum, can be improved in physical characteristics by alloying with other metals.

Aspirate: Breathe.

Atmosphere: (a) The blanket of air surrounding the earth. (b) A unit of pressure equal to 14.7 lbs. per square inch at sea level, and less at higher elevations.

Attrition: Wearing down by rubbing or by friction; abrasion.

Axis: The center line of a rotating part, a body of symmetrical cross-section, or a circular bore.

B

Babbitt: White metal used for lining bearing. Consists of tin, antimony, copper, and other metals.

Backlash: The lost motion between the teeth of two gears before actual driving contact begins.

Back Pressure: Pressure in an exhaust manifold. It is a disadvantage for an engine to exhaust against a high back pressure.

Bearing Groove: Channel cut in bearing surface to distribute oil.

Bevel Gear: Gear having teeth cut along a conical surface.

Blow-by: Cylinder gases escaping past pistons into the crankcase.

Bottom Dead Center (BDC): A point in crankshaft rotation when the piston is at the lower end of its stroke.

Brake Horsepower: The useful power delivered at the main engine shaft. This is done by measuring the engine's ability to turn against the resistance of an external brake. Brake horsepower equals torque in foot-pounds times engine revolutions per minute divided by 5,252.

$$\text{bhp} - \frac{\text{Torque x rpm}}{5{,}252}$$

Brake Mean Effective Pressure (bmep): Mean effective pressure acting on the piston which would result in the given brake horsepower output, if there were no losses due to friction and accessories. Equal to mean indicated pressure times mechanical efficiency.

British Imperial Gallon (B.I. Gallon): Is equal to 277.3 cubic inches.

British Thermal Unit (B.T.U.): approximate definition: The amount of heat required to raise 1 lb. of water one degree F.

Fact definition: 1/180 the amount of heat required to raise 1 lb. of water from freezing to boiling at standard atmospheric pressure.

Bushing: A liner of bearing material, inserted into a hole to insure a good wearing surface.

C

Cam: Device for producing controlled motion of any characteristic from a shaft, for example, which rotates at a uniform speed. Most common application in diesel work is for opening and closing valves at proper points in the engine cycle. (See camshaft.)

Cam Dwell: Portion of the cam holding the valve stationary in some particular position for a time.

Cam Follower: An intermediate part which is held in contact with the cam and to which motion is imparted by the cam. Cam followers are sometimes called valve lifters.

Cam Nose: Portion of the cam holding the valve in its widest open position.

Cam Roller: One type of follower where a roller makes contact with the cam.

Camshaft: Shaft on which cams are a part or attached.

Carbon Dioxide: A colorless, odorless gas which results when carbon is turned completely. Chemical formula; CO_2.

Carbon Monoxide: A colorless, odorless, poisonous gas resulting from the incomplete burning of carbon. Chemical formula; CO.

Centrigrade: A thermometer scale upon which the freezing temperature of water is 0°, and boiling temperature of water at atmospheric pressure is 100°.

Centrifugal: Tending to travel outwardly from the center and traveling in a circle.

Centrifugal Blower: Blower which, by means of a rapidly rotating impeller, displaces air or gas by centrifugal force.

Centrifugal Governor: Governor which employs varying force with change of speed in order to control the amount of fuel supplied to the combustion chambers.

Centrifugal Pump: A pump using the centrifugal force produced by a rapidly rotating impeller to displace liquid.

Cetane Valve: An indication of the self-ignition temperature of a fuel.

Circumference: The distance around a circle; hence, circuit around.

Combustion Chamber: Chamber in which combustion of fuel mainly occurs, corresponds to the space above the piston and below the cylinder head.

Compression Ignition: Ignition of fuel by the temperature compression alone.

Compression Pressure: Pressure in the combustion chamber at the end of the compression stroke, but without any fuel being burned.

Compression Ratio: The ratio of total volume in the cylinder when the piston is at B.D.C. to volume remaining when piston is at T.D.C.

Compression Release: Usually a device for preventing the intake valves from completely closing, thereby, permitting the engine to be turned over without compression.

Compression Ring: Piston ring designed to reduce gas leakage by the piston to a minimum.

Compression Stroke: That stroke of the operating cycle during which air is compressed into the space remaining above the piston.

Connecting Rod: Rod connecting the piston with the crankshaft (also referred to as a con rod). The con rod is the means by which the reciprocating motion of the piston is changed to rotating motion at the crankshaft.

Connecting Rod Bearing: The bearing surface for the end of the rod that is connected to the crankshaft. This bearing, due to physical characteristics, is usually referred to as an insert or shell.

Cooling System: Complete system for circulating water through the engine jackets, through a medium to cool water (radiator), and returning it to the engine.

Corrosion: An eating or gradual wearing away, as by the effect of chemical action. Something produced by corroding.

Counterweight: A weight mounted on the crankshaft opposite each crank throw to reduce vibration and also bearing loads due to inertia of moving parts.

Crankcase: The portion of the engine housing enclosing the crankshaft.

Crankpin: That part of a crankshaft to which the connecting rods are attached.

Crankshaft: A rotating shaft which receives the power from engine pistons through the connecting rods.

Crank Throw: One crankpin with its two webs. The distance from the center of the crankshaft to the center of the crankpin is indicative of the engine's stroke.

Crank Web: That part of the crankshaft which lies between the crankpin and the main bearing of the crankshaft.

Critical Compression Ratio: The lowest compression ratio at which any particular fuel will ignite by compression under prescribed test procedure. The lower the critical compression ratio, the better ignition qualities of the fuel.

Critical Speeds: Speed at which the frequency power strokes synchronize with the crankshaft's natural frequency of torsional vibration. Unless the crankshaft carries a torsional vibration damper, running the engine at one of its critical speeds for any length of time may result in a broken crankshaft.

Crosshead: Device to operate valves in pairs. The crosshead bridges a pair of valves to allow one valve rocker lever to operate both valves.

Cycle: Any series of events which continuously repeat, such as, intake, compression, power, and exhaust; hence, the term four stroke cycle. Not to be confused with "circle". A cycle does not necessarily have anything to do with rotating parts.

Cylinder: The circular bore in which the piston reciprocates. Also, the casting (engines without cylinder liners) in which this bore is machined; hence, the term cylinder block.

Cylinder Head: The part closing the end of the cylinder and containing the fuel injector, intake valves, and exhaust valves.

Cylinder Liner: Inner part of the cylinder; a sleeve forming the cylinder bore, which may be inserted or removed.

D

Dead Center: Either of the two positions when the crank and connecting rod are in a straight line at the end of the stroke.

Deceleration: Implying the slowing down of a speed. The opposite of acceleration. Also called negative acceleration.

Detonation: Burning of a portion of the fuel in a combustion chamber at a rate faster than desired. Commonly results in audible knocking caused by the burning fuel pressures opposing the upward movement of the piston on the compression stroke.

Diaphragm: A thin dividing membrane or partition.

Diesel Engine: An internal combustion engine having a fuel injected into the combustion chamber and igniting this fuel solely by the heat of compression.

Dissipate: In the unit material, this term is used with regards to the dispersing or dispelling of heat.

Distillate: The liquid (fuel oil) that results from distillation.

Dowel: A metal pin attached to one object which when inserted into a hole in another object insures proper alignment.

Drop-forging: A process of heating metal, placing it in a die, and shaping it by force from a drop hammer which operates on the principle of a pile driver.

Duralumin: An aluminum alloy of great strength and lightness. Is made up of aluminum plus copper, magnesium, and manganese.

Dynamometer: An instrument for measuring the power output of an engine. The power output may be measured in terms of torque or horsepower.

E

Eccentric: A disc whose axis is not in the center which results in its ability to change circular motion to reciprocating (up and down) motion.

Efficiency: The proportion of energy going into an engine which comes out in the desired form, or the proportion of the ideal which is realized.

Electrode: The poles or terminals of a battery. The positive pole is the cathode, while the negative pole is the anode.

Electrolysis: When two different metals, such as iron and copper are placed in contact with each other and immersed in water, electric currents flow through the water from one metal to the other in exactly the same manner as in a battery, and a corrosive action called electrolysis takes place. Although these currents are very weak, over a period of time they cause localized corrosion that weakens, pits, and sometimes eats completely through the metal.

Electrolyte: A liquid conducting medium such as the acid-water combination in a storage battery.

Elliptical: Oval or oblong figure with a regular curved boundary.

Emulsion: A combination or mixture of liquids having one suspended in the other and not soluble. Such a mixture is usually milky or thick as a result of minute globules in suspension (water in oil).

Engine Piston Displacement: The total volume the pistons of an engine displace as they move from bottom dead center to top dead center. The displacement of one piston can be found by figuring the area of the bore and multiplying by the stroke ($\frac{\pi d^2 \times \text{stroke}}{4}$ or $\pi r^2 \times$ stroke).

This product times the number of cylinders gives the total engine displacement.

Exhaust Manifold: The exhaust header with branches leading from each cylinder.

Exhaust Valve: Valve, located in the head, which, when opened, permits exhaust gas to flow from the cylinder.

F

Fahrenheit: A thermometer scale in which the freezing point of water is -32° while the boiling point of water is 212°.

Ferrule: A flared or thickened ring used to insure a tight joint (tubing).

Fillet: Concave molding which fills in the sharp corner formed by two parts lying at an angle to each other.

Firing Order: The order in which the cylinders, beginning with No. 1 cylinder, deliver their power strokes.

Flash Point: The temperature at which an oil will give off inflammable vapors under prescribed conditions.

Flywheel: Device for storing energy in order to carry piston over compression and minimize cyclical speed variations.

Foot-Pound: A unit of work. The amount of work expended in lifting a weight of one pound a vertical distance of one foot.

Four-Stroke Cycle: Cycle of events which is completed in four strokes of the piston, or two crankshaft revolutions.

Fulcrum: The support for a lever.

Full Floating Piston Pin: Piston pin free to turn in the piston bosses and in the connecting rod eye.

Furol: The Saybolt Furol Viscosimeter is used to test fuel and road oils, while the Saybolt Universal Viscosimeter is used to test lubricating oils.

G

Gallery: Passageway inside a wall or casting. The main oil gallery within the block supplies lubrication to all parts of the engine.

Gasket: Layer of material used between machined surfaces in order to seal them against leakage.

Gear Pump: Pump using the spaces between the adjacent teeth of gears for moving liquid.

Glow Plug: Heater plug, used in the cold starting aid, having a coil of resistance wire heated by a low voltage current, to ignite fuel sprayed into intake manifold.

Governor: Device used in the PT fuel system of controlling the speed of the engine.

Graphite: An iron-grey colored form of natural carbon. It is soft and is used as a lubricant.

Grommet: An endless ring.

H

Helix: A spiral formed on a circular object such as the thread on a screw.

Hexagon: A figure having six sides and six corresponding angles.

Homogenous: Having identical structure throughout. One portion of a substance having the same chemical make-up as another portion of the same substance.

Horsepower: The power necessary to raise 33,000 pounds one foot in one minute.

Continuous Horsepower: The horsepower an engine is capable of carrying at the corresponding stated speed for continuous full-load operation of more than 24 hours.

Intermittent Horsepower: The power an engine will develop at the stated speed and with good operating conditions. The engine must be capable of carrying this load for periods not exceeding 30 minutes if immediately followed by loads not exceeding the continuous horsepower rating, and the latter decreased load should exist for at least two times the period of the intermittent load.

Peak Horsepower: The maximum horsepower which the engine will develop and maintain without drop in speed for at least 1 minute, with a reasonably clean exhaust when the engine is in proper adjustment.

Horsepower-Hour: Unit of energy equivalent to that expended in one horsepower applied for one hour. Equal to 2545 B.T.U. (approximately).

Hydraulic: The use of liquids as a means of operation.

Hydrocarbon: A compound of hydrogen and carbon. Examples: benzines, paraffins, acetylenes, etc.

I

Ignition Time Lag: Time between start of injection and ignition.

Impeller: The blade or disc in a centrifugal pump.

Impinging: To physically strike or dash.

Impregnated: Saturated or permeated with another substance.

Indicated Horsepower: The actual power produced within the cylinder of an engine without taking into account any frictional loss.

Inertia: Matter that remains at rest or at uniform motion unless some outside force changes that state.

Injection System: Apparatus for delivering the correct quantity of fuel to the combustion chamber at the correct time and in the condition for efficient burning.

Injector: Device for introducing fuel into the combustion chamber. In the PT fuel system it meters and injects fuel.

Injector Cup: Part containing several orifices through which fuel is injected into the combustion chamber.

Intake Valve: Valve which admits fresh air to the combustion chamber of the engine.

Internal Combustion Engine: Heat engine using the products of combustion to produce power within the engine.

J

Journal: The portion of a shaft, crank, etc., which turns in a bearing.

K

Kinematic Centi Stokes: An alternate method of measuring the viscosity of an oil.

Kinetic Energy: The stored energy of a moving body as developed through its momentum.

Knurl: A series of ridges milled on the outer circumference of a piston or nut.

L

Lobe: The projecting part, such as the camshaft lobe.

Lubrication: The interposition of a low friction film between bearing surfaces.

M

Main Bearing: A bearing supporting the crankshaft.

Malleable: The quality of being easily hammered or rolled out without breaking.

Manometer: An instrument for measuring the elastic pressure of gases.

Mean: Similar in meaning to "average". To illustrate the difference between "mean" and "average", suppose an engine is called upon to deliver 100 bhp for only one minute, after which it delivers 50 bhp for 59 minutes. The average bhp is half way between the minimum power, or 75 bhp. The mean bhp takes into consideration the time each power was delivered:

$$\begin{array}{r} 1 \times 100 = 100 \\ 59 \times 50 = \underline{2950} \\ /3050 - 60 = 50.8 \text{ bhp} \end{array}$$

Mean Effective Pressure: The average useful pressure during four strokes of a four-cycle engine piston.

Molecule: The smallest part of a substance that can exist separately.

Muffler: Device for reducing noise of the exhaust.

Muriatic Acid: Hydrochloric acid.

N

Neck: That portion which is turned down to a smaller diameter than the main shaft of which it is part.

Neoprene: A synthetic rubber that is not affected by various chemicals harmful to natural rubber.

O

Octane Rating: An indication of the anti-knock properties of gasoline. This rating usually coincides with the amount of Ethyl fluid added to the regular gasoline.

Odometer: An instrument which when attached to a wheel of a vehicle, measures the distance traveled.

Ohmmeter: An instrument used to measure the number of ohms resistance in a circuit.

Oil Control Ring: Piston ring designed to keep excess oil off the cylinder walls.

Oil Cooler: A heat exchanger for lowering the temperature of oil.

Oil Filter: Filter intended to remove impurities from oil.

Oscillating Motion: To move back and forth as the swinging of a pendulum.

Otto Cycle: The four stroke cycle commonly used in internal combustion engines.

Overspeed Governor: A governor shutting off the fuel or stopping the engine only when excessive speed is reached.

Oxalic Acid: A white crystalline compound used in solution with other compounds as a cleaner to remove heavy mineral deposits in an engine.

P

Pawl: A hinged piece made to engage with ratchet teeth to prevent reverse motion.

Peen: To mushroom or spread the end of a pin or rivet.

Penetrometer: An instrument used to measure the consistency of greases.

Piston Crown: Top of the piston.

Piston Pin: The cross pin which links the piston to the connecting rod.

Piston Skirt: That part of the piston below the piston pin hole.

Pitch Diameter: (Gear) is equal to 3.1416 divided by the pitch circle. The pitch circle is the circumference measured along the pitch points (one-half the working depth of each tooth).

Poppet Valve: A valve having a mushroom shaped head.

Pour Point: The lowest temperature at which an oil will flow.

Projected Area (Main Bearing): That part of the bearing which comes in actual contact with the shaft journal.

Prussian Blue: A blue pigment, useful in determining area of contact between two surfaces.

Push Rod: Rod used for transmitting cam motion to a valve or injector.

Pyrometer: A gauge used to measure very high temperatures accurately.

R

Radiator: A heat exchanger in which cooling water gives up heat to the air without coming into direct contact with it.

Rebore: Bore out a cylinder slightly larger than original size.

Rheostat: An instrument which permits manually varying the amount of electric current.

Ring Groove: Groove machined in piston to receive piston ring.

Roots Blower: An air pump or blower similar in principle to a gear type pump (supercharger).

S

Saybolt Viscosity: The number of seconds necessary for 60 milliliters of liquid to pass through the outlet tube of a Saybolt Viscosimeter under standard test conditions.

Scavenging: The displacement of exhaust gas from the combustion chamber by fresh air.

Serrated: Notched or having teeth like a saw.

Solenoid: A coil of wire usually wound in the form of a helix used in conjunction with an electro-magnet.

Specific Gravity: The ratio of the weight of a body or substance to that of an equal volume of a known or standard substance. When measuring liquids, water is the standard for measure. When measuring gasses, air or hydrogen is the standard use.

Speed Droop: The percentage of speed reduction which occurs when the load on an engine is changed from zero to full load.

Spherical: In the shape of a sphere or ball.

Splined Shaft: A grooved shaft which will allow movement with a mating splined surface which it is engaged with while rotating.

Spur Gear: Gear having teeth cut on outer circumference, parallel with the axis.

Stellite: An alloy of cobalt, chromium, and tungsten and contains no iron.

Stress: The cohesive force within a material to resist strain or deformation.

Stroboscope: An instrument which, with the aid of a beam of light, can enable a person to examine a point on a rapidly revolving body. The light beam is interrupted and when it flickers at the same rpm as the revolving part, the part seems to stand still (synchronized).

Sump: A receptacle into which liquid drains, such as the portion of the engine crankcase which carries the lubricating oil.

Supercharger: An air blower used to fill engine cylinders at a higher pressure than atmospheric.

Swept Volume: The volume above the piston after it has reached the top of its stroke.

Symmetrical: Equally balanced or evenly proportioned.

T

Tachometer: An indicator which shows the speed of rotation.

Terplate: A pattern.

Tensile: The resistance of a material to be pulled apart in the direction of its grain.

Throttling: Restricting the flow of a liquid, usually by cutting down the free area of passage.

Thrust Bearing: A bearing which restrains end-wise motion of a turning shaft, or withstands axial loads instead of radial loads as does a common bearing such as the connecting rod bearing.

Timing Gear: The gear by which the camshaft is driven from the crankshaft.

Tocco Hardening: A process of hardening steel parts by first electrically heating and then quenching in water.

Torque: The turning effort applied to a shaft. Measured in foot-pounds (the distance out from the centeraxis in feet times the number of pounds of twisting effort).

Tungsten: A heavy metallic element of steel grey color.

Turbocharger: Centrifugal air pump or blower driven by exhaust gas turbine. It fills engine cylinders with fresh air at a higher pressure than atmospheric.

Turbulence: A state of being in violent motion and agitation.

V

Vacuum: Absence of pressure. Pressure less than atmospheric.

Valve-In-Head: Valves seating in cylinder head and opening downward into combustion chamber.

Velocity: Rate of motion.

43

Viscosity: Resistance to flow.

Viscosity Index: An arbitrary number which, when applied to a lubricating oil, indicates the rate at which its viscosity changes with increased or decreased temperature.

Volatility: The ability to evaporate or change to a gaseous state.

Volumetric Efficiency: The ratio of the weight of air actually found in a cylinder when operating as compared to the weight of air which would be found in the same volume under static conditions under normal atmospheric pressure.

W

Wet Liner: A liner which comes in direct contact with cooling water.

Work: A form of energy. Product of force times distance.

44

PREPARE THE MAN CISDT-PI-47-1

Technical Training

Programmed Learning

FIRE SAFETY

8-9

3 October 1969

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes CISDT-PI-47-1, 12 June 1969.

Designed For ATC Course Use

Training Publications are designed for ATC course use only. They are updated as necessary for training purposes, but are not to be used on the job as authoritative references in preference to Technical Orders or other official publications.

OBJECTIVES

Upon completion of this program you will be able to:

1. List the three steps in the procedure for reporting fires.
2. List the three elements that must be present to produce a fire.
3. List the three general classes of fires.
4. List the type of fuel that supports each of the three classes of fires.
5. List the type of extinguisher to use for different classes of fires.
6. List the methods of combating the different classes of fires.

VALIDATION

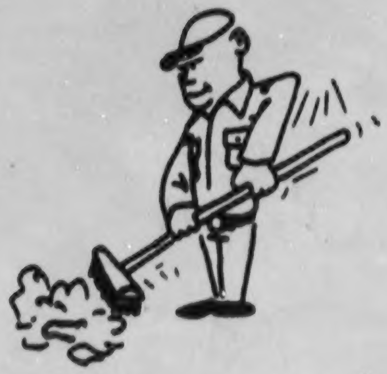
This programmed text was developed for use in 3ABR47330, Automotive Repairman's course. Of 100 students from this course who were used in the validation exercise, 93 achieved the objectives as stated. This programmed text has been used to train more than 20,000 students in the 31, 42, 44, and 47 career field.

INSTRUCTIONS

This program presents information in small steps. Each page or "frame" contains an information panel and/or questions pertaining to information contained in the last information panel. Read the information presented within the solid-line box then select the correct statement in response to the questions asked in the question-mark outlined box. Read the questioning statement and then make your response after the appropriate question number on the answer sheet provided. MAKE NO MARKS IN THIS PROGRAM. The small step size of the information panel makes selection of the correct response an easy matter, and in most cases you won't have to be told the correct response. However, the last page of this program contains a complete list of the correct response letters listed by question numbers. Feel free to consult this list at any time you are in doubt as to the correctness of any of your response choices.

DO NOT MARK IN THIS PROGRAM

August 1969



Fire prevention is a requirement of safety. One of the best fire prevention systems is good housekeeping. Learning a few precautions will cut down the possibility of fire in your place of work.

Question 1.

? ?

Which of these statements is correct?

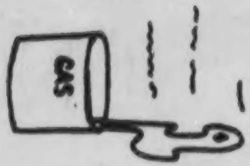
a. To reduce fire hazards, work areas should be kept free of trash.

b. There is no relationship between fire and housekeeping.

c. The possibility of fire is non-existent where you work.

? ?

Frame 2.



Flammable liquids also contribute to causes of fires. You should be very careful not to spill flammable liquids because they create highly combustible vapors which are easily ignited.

Question 2.

? ?

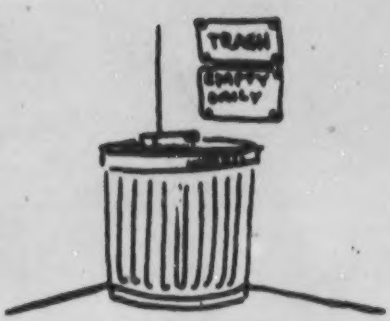
Which of these statements is correct?

a. Gasoline should be used for cleaning parts.

b. Common causes of fire are poor housekeeping and careless use of flammable liquids.

c. Evaporating gasoline does not constitute a fire hazard.

? ?



Trash and flammable liquids should be kept in closed metal containers.

Question 3.

Which of these statements is correct?

a. Oily rags should not be stored in closed metal containers.

b. Fuels, cleaning solvents, and paints should be kept in closed metal containers.

c. Trash is not flammable.

Frame 4.

Question 4.

? ?

? Which of these statements is correct? ?

? a. Flammable liquid vapors are not easily ?
ignited.
? ?
b. Gasoline may be used as a cleaning
? solvent. ?

? c. The most common causes of fires are ?
poor housekeeping and careless use of
? flammable liquids. ?

? ?

Question 5.

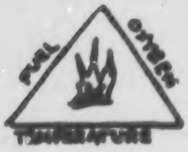
? ?

? Which of these statements is correct? ?

? a. Flammable liquids, fuels, trash, and ?
paints should be kept in closed
? metal containers. ?

? b. Flammable liquids do not constitute ?
a fire hazard.
? ?
c. Flammable liquids, rags, fuels,
? trash, and paints should be kept ?
in the shop where they are used.
? ?

? ?



There must be three elements present to produce a fire: fuel, oxygen (air), and a temperature high enough to cause combustion. Elimination of any one of these elements will extinguish a fire.

Question 6.

? ?

? Which of these statements is correct? ?

? a. Cooling a fire below the combustion temperature will not extinguish it. ?

?

? b. Without sufficient temperature, air, or fuel a fire will be extinguished. ?

? c. Cutting the oxygen off from a fire will not extinguish it. ?

?

? ?

Frame 6.

There are three general classes of fires: Class A, Class B, and Class C. Each of these is classified according to the type of fuel supporting the fire.

Question 7.

? ?

Which of these statements is correct?

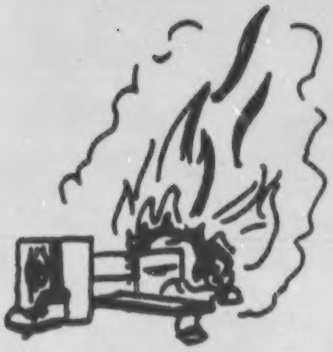
a. There are four general classes of fires.

b. The class of fire is determined by the ignition temperature of the fuel.

c. The classes of fires are A, B, and C.

? ?

Frame 7.



Class A fires consist of fuels such as trash, wood, rags, paper or similar materials.

Question 8.

? ?

? Which of these statements is correct? ?

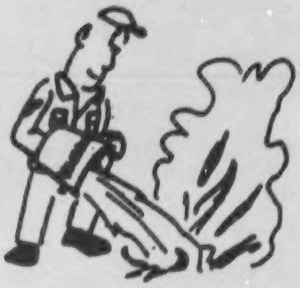
? a. Burning wastepaper is a Class A fire. ?

? b. Burning gasoline is a Class A fire. ?

? c. Burning paint is a Class A fire. ?

? ?

Frame 8.



Trash, wood, and paper (Class A) fires can be effectively and safely extinguished by quenching or cooling with water or solutions containing water.

Question 9.

? ?

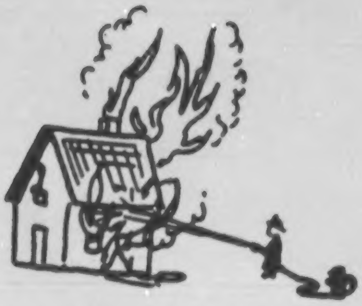
Which of these statements is correct?

a. Water solutions extinguish fires by cutting off the fuel supply.

b. Water is a suitable extinguishing agent for use on Class A fires.

c. Water extinguishes Class A fires by eliminating the air supply to them.

? ?



The method of combating Class A fires is primarily to reduce the temperature of the fuel below the burning point. An example of this is using water hoses on a burning building.

Question 10.

? ?

Which of these statements is correct?

a. Class A fires are most effectively extinguished by cooling.

b. A burning aircraft is a Class A fire.

c. Water will spread a Class A fire.

? ?

Frame 10.

Question 11.

? ?

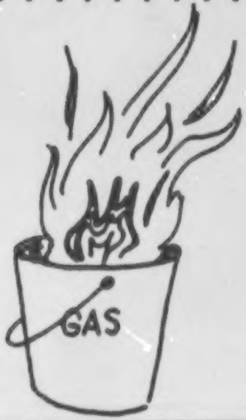
? Which of these statements is correct? ?

? a. Cooling a fire will not extinguish it. ?

? b. Cutting off the air supply to a fire will not extinguish it. ?

? c. Class A fires consist of burning rubbish, wood, paper, or rags. ?

? ?



Class B fires are those that consist of flammable liquid fires.

Question 12.

? ?

? Which of these statements is correct? ?

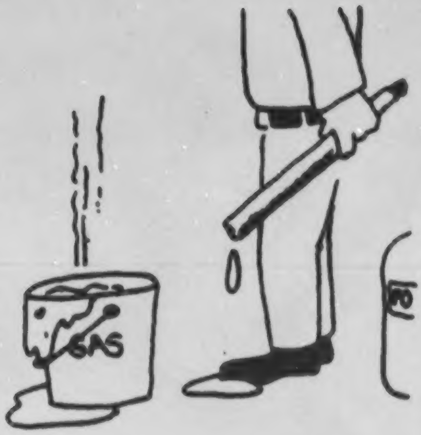
? a. A forest fire is a Class B fire. ?

? b. Burning trash or rags are Class B fires. ?

? c. Burning paint, kerosene, or gasoline constitute Class B fires. ?

? ?

Frame 11.



Fuel, solvent, and oil fires (Class B) are best extinguished by smothering with agents such as foam.

Question 13.

? ?

Which of these statements is correct?

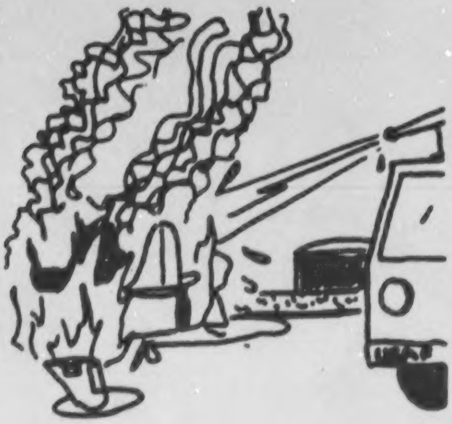
a. Foam cannot extinguish paint and grease fires.

b. Foam is a suitable extinguishing agent for use on Class B fires.

c. Foam extinguishes fires by cutting off the fuel supply.

? ?

Frame 12.



The method of combating Class B fires is primarily to smother them without spreading them. An example of this is spraying foam on an aircraft crash.

Question 14.

? ?

? Which of these statements is correct? ?

? a. Foam covers the top of burning liquid and cuts off the air to the fire. ?

? b. A burning house is a Class B fire. ?

? c. Water will float on Class B fires and extinguish them. ?

? ?

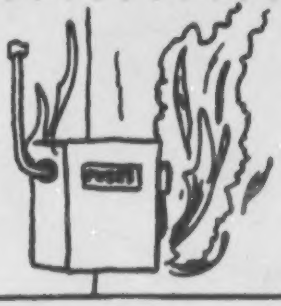
Question 15.

Which of these statements is correct?

a. Eliminating the fuel supply to a fire will not extinguish it.

b. Class B fires consist of burning flammable liquids.

c. Class B fires consist of burning electrical equipment.



Class C fires consist of burning electrical equipment.

Question 16.

Which of these statements is correct?

a. Burning gasoline is a Class C fire.

b. A burning electrical motor is a Class C fire.

c. Burning wood is a Class C fire.

Frame 14.

Electrical equipment fires (Class C) must be extinguished using a non-conducting smothering agent such as chlorobromomethane (CB).

Question 17.

? ?

? Which of these statements [illegible] correct? ?

? a. Water is a suitable extinguishing ?
agent for Class C fires.

? ?

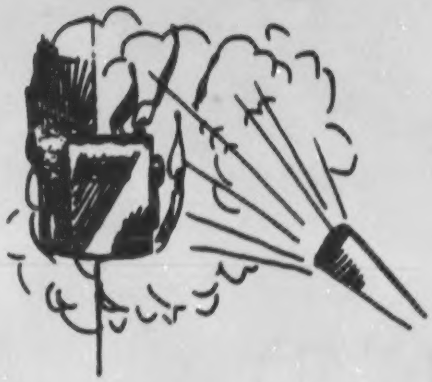
b. CB will not smother a Class C fire.

? ?

c. CB can be used on electrical equip- ?
ment fires because it does not
conduct electricity.

? ?

? ?



The method of combating Class C fires is primarily by smothering, without spreading it and without being electrocuted.

Question 18.

? ?

? Which of these statements is correct? ?

? a. Class C fires are best extinguished by cutting off the air to them. ?

? ?

? b. Water will confine a Class C fire without danger. ?

? c. There is no danger connected with combating Class C fires. ?

? ?

? ?

Frame 16.

Question 19.

Which of these statements is correct?

a. Class C fires consist of burning trash.

b. Class C fires consist of burning flammable liquids.

c. Class C fires consist of burning electrical equipment.

Chlorobromomethane can also be used to smother Class B fires. Remember, the chemical agent CB can be used on both Class C and B fires. (CB on C and B.)

Question 20.

? ?

? Which of these statements is correct? ?

? a. CB can be used on an oil or generator fire. ?

? ?

? b. CB should be used to extinguish Class A fires. ?

? c. Both "a" and "b" above are correct. ?

? ?

Frame 18.

Carbon dioxide (CO_2) is another extinguishing agent that can be used on Class B and C fires. This agent is an inert gas that displaces the air surrounding the fire. It is also a non-conductor of electricity.

Question 21.

Which of these statements is correct?

a. Carbon dioxide should be used on Class A and B fires.

b. Carbon dioxide and CB are suitable agents to use on Class B fires.

c. Carbon dioxide is the only suitable extinguishing agent to use on Class C fires.

Question 22.

? ?

? The types of extinguishing agents recommended ?
for use on Class A fires are
? ?
a. water or solutions containing water.
? ?
b. CB and foam.
? ?
c. carbon dioxide and water.
? ?

? ?

Question 23.

? ?

? The types of extinguishing agents recommended ?
for use on Class B fires are
? ?
a. water and CB.
? ?
b. foam, carbon dioxide, and CB.
? ?
c. carbon dioxide and water.
? ?

? ?

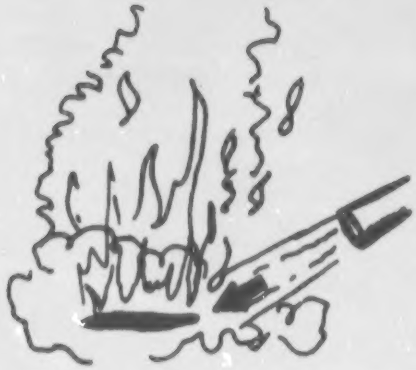
Question 24.

? ?

? The types of extinguishing agents recommended ?
for use on Class C fires are
? ?
a. carbon dioxide and water.
? ?
b. carbon dioxide and CB.
? ?
c. foam and CB.
? ?

? ?

Frame 20.



To be most effective, fire extinguishing agents must be directed to the part of the fire where the burnable vapors mix with air and ignite. This is just at the surface of the fuel where the flames originate.

Question 25.

? ?

? Which of these statements is correct? ?

? a. Extinguishing agents are more effective if applied above the flames. ?

? ?

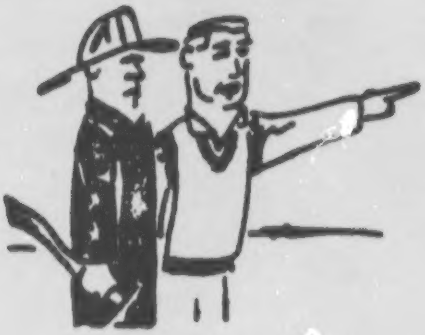
b. You should direct water to the base

? of a Class C fire. ?

? c. To be most effective, extinguishing ?
agents should be directed at the

? base of a fire. ?

? ?



If you report a fire, give your name and the location of the fire. Then stand by to direct the fire crews to the fire if they need directions.

Question 24.

Which of these statements is correct?

a. You should never report a fire.

b. After reporting a fire you need not remain in the area of the fire.

c. When reporting a fire you should give your name and the location of the fire.

Frame 22.

Question 27.

? ?

Which of these statements is correct?

- a. To effectively extinguish a fire, the extinguishing agent should be directed at the base of the fire.
- b. Fire extinguishing agents are most effective when directed at the center of the flames of a fire.
- c. Both "a" and "b" above are correct responses.

? ?

Response Confirmation Panel

Question Number	Correct Answers	Question Number	Correct Answers
1.	a.	15.	b.
2.	b.	16.	b.
3.	b.	17.	c.
4.	c.	18.	a.
5.	a.	19.	c.
6.	b.	20.	a.
7/	c.	21.	b.
8.	a.	22.	a.
9.	b.	23.	b.
10.	a.	24.	b.
11.	c.	25.	c.
12.	c.	26.	c.
13.	b.	27.	a.
14.	a.		

68

PREPARE THE MAN

232
PROGRAMMED TEXT 3ABR47~~330~~-PT-101B
3ABR42133-PT-101C
3ABR47231-PT-103
3ABR47230-PT-102B

Technical Training

General Purpose Vehicle Repairman
Aerospace Ground Equipment Repairman
Special Vehicle Repairman
Base Maintenance Equipment Repairman

8-9

SHOP SAFETY

14 January 1974

AIR TRAINING COMMAND

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-101B, 3ABR42133-PT-101C, 3ABR47231-PT-103, 3ABR47331-PT-101B, 3ABR42231-PT-108A, 7 August 1970.
OPR: TWS
DISTRIBUTION: X
TWS - 600; TAS - 2000; TTOC - 5

Designed For ATC Course Use

FOREWORD

This programmed text was validated on students enrolled in the 3ABR47330 Course in 1964. It has proved to be successful since that time.

OBJECTIVES

After completing this programmed text you will be able to select from a list of shop safety precautions those that pertain to the following items with 100% accuracy.

1. Fire
2. Welding and body shop
3. Battery shop
4. Improper tool usage and storage
5. Lifting and hoisting
6. Good housekeeping
7. Electrical equipment

The personnel in a shop are continually exposed to numerous hazards. Some activities are extremely hazardous; others which are non-hazardous can become hazardous due to carelessness, overconfidence, etc. Inexperienced personnel can sometimes create hazardous situations. Hazards are present during all normal activities, but their existence doesn't mean that an accident must occur. Our job is to prevent accidents, even under hazardous situations.

QUESTION 1.

? ?

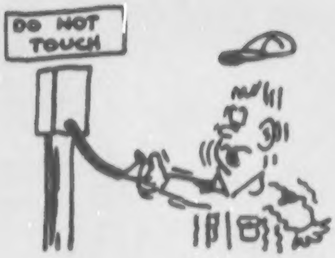
? Which of the statements below is most true? ?

? a. Personnel are subject to hazards in the maintenance shop only when they become careless. ?

? b. Personnel are subject to hazards in a maintenance shop during all normal activities. ?

? ?

Frame 2.



Inefficiency, personal injury, and property damage are the results of accidents in the maintenance shop. In order to reduce this waste of time and money, prescribed safety standards must be observed by all personnel at all times.

QUESTION 2.

? ?

? To promote efficiency and reduce the possibilities of personal injury and property damage, all personnel must ?

? a. prevent accidents in the maintenance shop. ?

? b. reduce waste in time and money. ?

? c. observe prescribed safety standards. ?

? ?

Some operations in a maintenance shop are hazardous to other operations within the shop. For instance, open welding could cause severe eye burn to personnel who look at the welding arc. Or, an explosion could occur if an acetylene torch is used where fuel vapors or paint fumes are present. For this reason painting, welding, and battery work will be accomplished in separate parts of the shop that are isolated from each other.

QUESTIONS 3 through 5.

? ?

3. Painting, welding, and battery work are isolated from each other in order to
   a. Prevent one operation from being hazardous to another.
   b. eliminate the hazards involved in each operation.

4. To prevent one operation from being hazardous to another the painting, welding, and battery work will be performed in
   a. the same shop.
   b. separate parts of the shop.

5. The painting, welding, and battery shops should be
   a. kept close together to minimize equipment duplication.
   b. isolated from each other.

? ?

Frame 4.

A major hazard in the maintenance shop is the possibility of fire due to the constant exposure of flammable fuels, lubricants, and other compounds. Also, parts, tools, work benches, and floors often become saturated with these flammable materials. Extreme care must be taken at all times to prevent shop fires from occurring under the conditions which always exist in any shop.

QUESTION 6.

? ?

? To prevent fires in the shop we see to it that ?

? ?

? a. no flammable materials are exposed in the shop area. ?

? b. Parts, tools, work benches, and floors don't become saturated with flammable materials. ?

? c. extreme care is exercised at all times. ?

? ?

Some prescribed safety standards which must be observed for the prevention of shop fires are:

a. Only explosion-proof electrical equipment and fixtures will be used in the paint shop.

b. Use of flame-producing equipment will not be permitted in the shop except in specified areas, such as the welding shop, where the required safety controls exist.

c. Smoking will be permitted in designated smoking areas only.

QUESTIONS 7 through 9.

? ?

Indicate whether the following statements are TRUE or FALSE.

7. Electrical equipment and fixtures in the paint shop must be flame-producing.

   a. TRUE

   b. FALSE

8. The use of flame-producing equipment is permitted only in areas where the required safety controls exist.

   a. TRUE

   b. FALSE

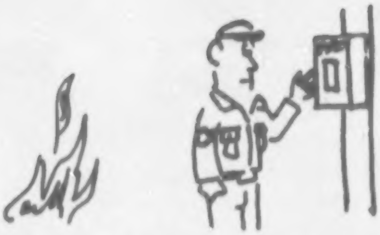
9. Smoking is not allowed except in designated smoking areas.

   a. TRUE

   b. FALSE

? ?

Frame 6.



If a fire should occur in your shop, be sure that a valid alarm is turned in. A valid alarm is one which tells responsible people, equipped to fight fires, the location of the fire and the name of the person turning in the alarm. Don't fail to turn in an alarm because you think the fire is too small. After the alarm has been turned in, use your best judgement to decide on whether to clear the building or attempt to extinguish the fire.

QUESTION 10.

? ?

? In case of fire in the shop, you should ?

? a. clear the building of as much equipment as possible. ?

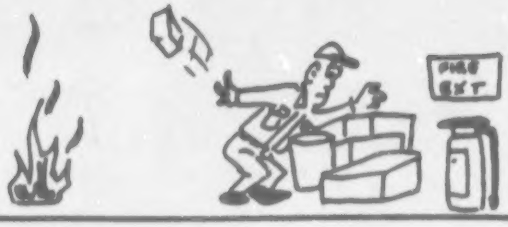
? ?

? b. yell "FIRE" and make sure that everyone is out. ?

? c. turn in an alarm. ?

? ?

Frame 7.



The importance of fire extinguishers being kept in good working order and being conveniently located throughout the maintenance shop cannot be overstressed. Their location will be clearly marked and kept free of obstructions at all times. They must be placed where they can be easily reached but where they cannot be accidentally bumped by personnel or equipment.

QUESTIONS 11 and 12.

? ?

11. Where will fire extinguishers be located?
    - a. Anywhere handy.
    - b. Away from personnel and equipment.
    - c. Where they can be easily reached but not in the way of personnel and/or equipment.

12. How will fire extinguisher locations be kept?
    - a. No special way as long as they can be seen.
    - b. Clearly marked and free of obstructions.
    - c. Clean and free of grease and oil.

? ?

Frame 8.

Now, we are going to see how much you have learned so far about Shop Safety. Indicate whether each of the 10 following statements (on this and the next page) are either TRUE or FALSE.

? ?

13. The normal activities of a repair shop present numerous hazards to maintenance personnel.

    a. TRUE
    b. FALSE

14. Prescribed safety standards must be observed by all personnel in order to promote efficiency and reduce the possibility of personal injury and property damage.

    a. TRUE
    b. FALSE

15. Painting, welding, and battery work is accomplished in separate parts of the shop to prevent one operation from being hazardous to another.

    a. TRUE
    b. FALSE

16. Fire hazards exist in a shop due to the exposure of flammable materials and the saturation of parts, tools, work benches, and floors with flammable materials.

    a. TRUE
    b. FALSE

17. The electrical equipment and fixtures used in Air Force paint shops must be explosion-proof.

    a. TRUE
    b. FALSE

18. Flame-producing equipment must be used only in specified areas, such as the welding shop, where required safety controls exist.

    a. TRUE
    b. FALSE

? ?

CONTINUED ON NEXT PAGE

? ?

19. Smoking in the shop is forbidden except in designated areas.
    a. TRUE
    b. FALSE

20. Never attempt to extinguish a fire without turning in an alarm first.
    a. TRUE
    b. FALSE

21. Fire extinguisher locations will be clearly marked and kept free of obstructions.
    a. TRUE
    b. FALSE

22. Fire extinguishers will be placed where they can be easily reached, but cannot be accidentally bumped by personnel or equipment.
    a. TRUE
    b. FALSE

? ?

Frame 10.

Another dangerous and often unnecessary fire hazard is created by the fueling of equipment inside the shop. As an added precaution against fire, equipment will not be fueled inside the shop as a routine practice. They may be fueled inside, however, under controlled conditions but then only when approved by the Installations Fire Marshall.

QUESTION 23.

? ?

? When may equipment be fueled inside the maintenance shops? ?

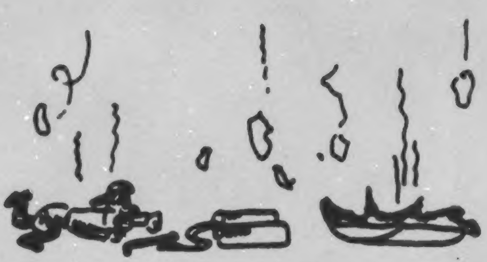
? ?

? a. Anytime, unless a directive from the Installations Fire Marshall prohibits it. ?

? b. Only under controlled conditions and then only on approval of the Installations Fire Marshall. ?

? c. Whenever necessary as a routine practice. ?

? ?



Working on fuel tanks is always a hazardous task. Explosions from fuel vapors can occur very easily. Before welding or other heat-producing work is done on gas tanks and other fuel containers, they should be drained, flushed out with water and, when practicable, filled with water. Filling with water will eliminate the danger of explosion and fire from fuel vapor inside the tank.

QUESTION 24.

? ?

? Before welding a fuel tank of any kind, it must be ?

? ?

a. filled with water.

? ?

b. drained, flushed and, when practicable, filled with water. ?

? ?

Frame 12.

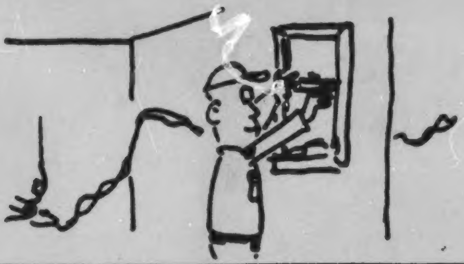
Another fire hazard which must be avoided is the one created when used oil, fuel, or other flammable liquids are poured into floor drains. An explosion hazard from vapors is created not just in your own building but in all other buildings through which the drain system runs. To prevent this hazard, flammable liquids will be put in metal containers which, when full, will be carried to some remote area and dumped.

QUESTION 25.

? ?

? The proper disposal of used flammable liquids is ?
accomplished by
? ?
a. flushing them down the floor drain system.
? ?
b. carrying them to a remote area to be
? dumped. ?

? ?



General exhaust ventilation should be provided and used to prevent any accumulation of carbon monoxide gas inside the shop. These accumulations could come from engine exhaut manifold leaks, defective mufflers, or vehicles entering and leaving the shop.

QUESTION 30.

? ?

? General exhaust ventilation will be provided and used in the maintenance shop in order to ?

a. prevent carbon monoxide from any source from accumulating in the shop.

b. allow the running of engines without directing the fumes outside the shop.

? ?

Remember, safety depends on you. If you know the safe procedures but do not practice them, you are at fault. On the other hand, you cannot practice safety if you don't know what the prescribed safety standards are. Our job is to teach you these standards. The rest is up to you.

Frame 16.

Let's stop again and review some of the things we've covered so far. Indicate whether each of the 6 following statements are TRUE or FALSE.

QUESTIONS 31 through 36.

? ?

31. The most common personnel hazard in the maintenance shop is fire.

a. TRUE

b. FALSE

32. Before welding on a gas tank it must be drained and flushed.

a. TRUE

b. FALSE

33. Vehicles may be fueled inside the shop under controlled conditions unless a directive from the Installation FIRE MARSHALL prohibits it.

a. TRUE

b. FALSE

34. Flammable liquids should never be drained into floor drains.

a. TRUE

b. FALSE

35. Battery rooms, painting booths, and confined welding areas will be provided with special exhaust ventilation.

a. TRUE

b. FALSE

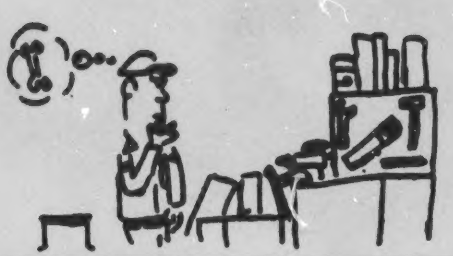
36. Flexible tubing must be attached to the vehicle's exhaust whenever the equipment's engine is run inside the shop.

a. TRUE

b. FALSE

? ?

Frame 17.



Good housekeeping is essential to the safety and efficiency of shop operations. Imagine a shop with nothing in its right place, floors cluttered with junk, and oil and grease spilled all over the place. You wouldn't get much work done because of all the tripping and slipping you would be doing, and the chances are that you would wind up in the hospital with a serious injury.

QUESTION 37.

? ?

? Safe shop operation depends on ?

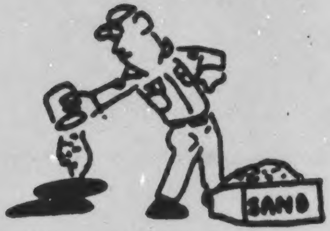
? a. using personal protective equipment. ?

? b. good housekeeping. ?

? c. applying only those shop safety practices necessary to keep the inspectors off your back. ?

? ?

Frame 18.



Shop floors will be kept clean and free of oil, grease, gasoline, water, and other hazardous or slippery material. Boxes of sand or other suitable absorbent materials will be provided to use on spilled grease and oil. After the absorbent material has been applied to spills, the floor will be thoroughly cleaned.

QUESTION 38.

? ?

? To clean up a grease or oil spill, you will use ?

? a. sand or other absorbent material. ?

? b. a rag dipped in solvent. ?

? ?

There are many hazardous operations which must be performed continually in the maintenance shop. To make these operations less hazardous, the Air Force provides the best personal protective equipment available. You are responsible for using this equipment. Personal protective equipment includes such items as face shields, impact goggles, rubber and asbestos gloves, chemical goggles, welding helmets, aprons, etc. This equipment will be kept in good condition and will be conveniently located for immediate use.

QUESTION 39.

? ?

? The Air Force provides personal protective equipment in the maintenance shop to ?

? ?

? a. eliminate the possibility of an accident while performing hazardous operations. ?

? b. make operations less hazardous. ?

? ?

Frame 20.

When working with batteries in the battery shop, personnel must be careful to wear the prescribed personal protective equipment. Battery acid, spilled on your clothing will "eat" holes in them and, if splashed in your eyes, could blind you permanently.

QUESTION 40.

? ?

? To protect your eyes and clothing while working with batteries, you must wear ?

? ?

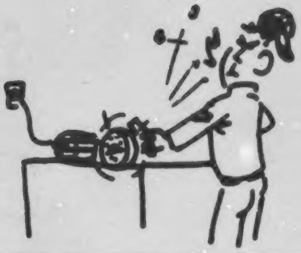
? a. impact goggles, steel-toed shoes, and asbestos gloves. ?

? b. chemical goggles, rubber gloves, and a rubber apron. ?

? ?

? ?

Frame 21.



Your eyes are your most valuable asset and they must be constantly protected against injury while working in the maintenance shop. When using a grinding wheel or cutting wheel which produces flying chips or dust, impact goggles or a face shield must be worn. You also need protection from dirt entering your eyes while working on your back under equipment.

QUESTION 41.

? ?

? You must wear goggles or a face shield to protect ?
your eyes when
? ?

a. using a grinding wheel or cutting device
? which produces chips or dust. ?

? b. working under equipment. ?

? c. both "a" and "b" above. ?

? d. neither "a" nor "b" above. ?

? ?

Frame 22.

The things we have covered so far have been in a variety of areas but, then, shop safety is a big order and includes several areas we cannot even cover in this program. Safety is a continuousthing. You may get by for a while neglecting the rules for safety, but sooner or later it can happen - serious injury or even death.

QUESTION 42.

Safety in the maintenance shop is dependent on

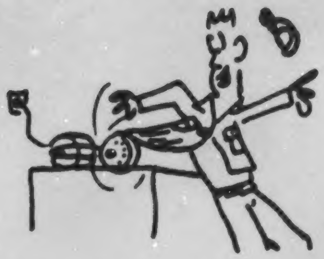
a. good common sense.

b. constant obedience to prescribed safety standards.

c. good housekeeping.

d. all of the above.

Frame 23.



Let's move into the area of personal clothing. The type of clothing you wear on the job is very important. Your clothes should be of a good comfortable fit but not too loose. Loose clothing is easily caught on machinery and may cause serious injury. Neckties, rings, and other jewelry will not be worn for the same reasons. Clothing which has become saturated with flammable substances will not be worn or stored in lockers as this constitutes a fire hazard. The job itself will determine how often you should change. Here again, good common sense must be used.

QUESTION 43.

? ?

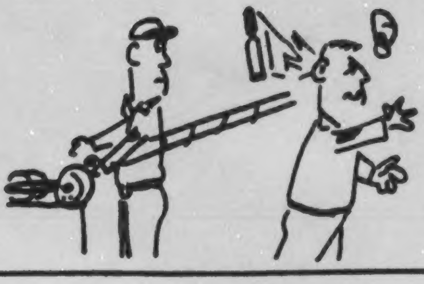
? Why must loose clothing, rings, or other jewelry ?
not be worn while working on or around equipment?
? ?

a. They can be easily caught on machinery and other equipment causing serious injury.

b. To keep from damaging machinery and equipment.

? ?

Frame 24.



Shop machinery which performs operations under power can be dangerous. The point of operation where the machine does its work, as well as gear trains, shafts, belts, drives, chain and sprocket drives must all be guarded according to standards set forth in the Ground Safety Manual. Machine guards are put in place for your protection. They will not be removed or blocked out of the way under any circumstance.

QUESTIONS 44 and 45.

? ?

44. Machine guards may be removed or blocked

a. whenever necessary to get maximum utilization of the machine.

b. only on approval of the maintenance officer for specific jobs.

c. never during operation.

45. What is the reason for having machine guards on machinery in the maintenance shops?

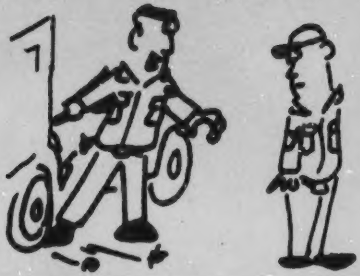
a. To prevent damage to the machine.

b. To protect personnel from injury.

c. Both "a" and "b" above.

d. Neither "a" nor "b."

? ?



A very important piece of equipment used in the maintenance shop is the equipment lift or hoist. Its purpose is to raise the equipment so that personnel can work underneath. Needless to say, all such lifts must be equipped with a safety device to prevent unintentional or accidental lowering.

There are two types of lifts commonly used. One is the roll-on or drive-on type; the other is the frame contact or chassis-lift type. All roll-on type lifts will be equipped with stop chocks, preferably automatic, which spring into place when the equipment enters the lift.

QUESTIONS 46 and 47.

? ?

? 46. What safety feature must all equipment lifts ?
be equipped with?

?
a. Stop chocks which prevent the equipment ?
from moving while on the lift.
? ?

b. A device which prevents accidental
? lowering of the lift. ?

? 47. What additional safety features must all ?
roll-on type lifts be equipped with?
? ?

a. Non-skid paint.

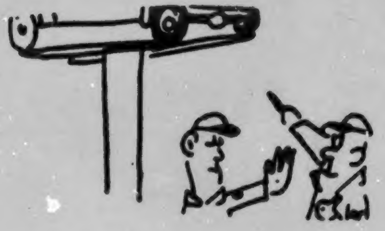
? b. Side rails. ?

c. Stop chocks.
? ?

d. Safety leg.
? ?

? ?

Frame 26.



No person will be permitted to remain with the equipment on the lift, when it is on a lift that is moving or is elevated.

QUESTION 48.

? ?

? When will persons be permitted to remain with the ? equipmetn on moving or elevated lifts.

? ?

a. Only when the engine is running.

? ?

b. Only if the engine is not running.

? ?

c. During brake bleeding operations.

? ?

d. Not under any circumstance.

? ?

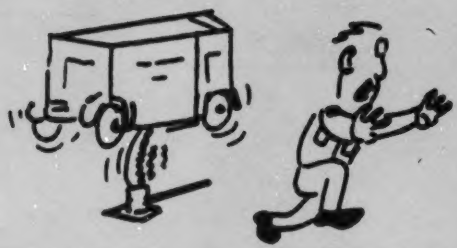
? ?

Frame 27.

You must inspect a lift for proper operation and condition prior to raising equipment; that is, determine if all safety devices are working properly.

However, when using a jack for lifting equipment there are still more safety precautions that must be observed.

Frame 28.



When using a jack you must be sure that it has a rated capacity sufficient to lift and sustain the load. That is, make sure that the jack is not too small for the job. All jacks, except those supplied by the manufacturer as standard equipment, will be stamped with their rated capacity in a prominent location on the jack. Once the equipment has been raised by a jack the equipment must be securely blocked up with "jack stands" to prevent its falling. Even after the equipment is jacked up and securely blocked, you will not place any part of your body directly under the wheels of the equipment.

QUESTIONS 49 through 52.

? ?

? Indicate whether each of the 4 following statements is TRUE or FALSE. ?

? ?

? 49. All jacks except standard-equipment jacks must be stamped with their rated capacity. ?

? a. TRUE ?

? b. FALSE ?

? 50. The rated capacity of a jack is the amount of weight it will lift and sustain safely. ?

? a. TRUE ?

? b. FALSE ?

? 51. If the jack is rated to sustain the weight of equipment safely there is no need of securely blocking up the equipment after it has been jacked. ?

? a. TRUE ?

? b. FALSE. ?

? 52. You will not place any part of your body directly under the wheels of securely blocked equipment. ?

? a. TRUE ?

? b. FALSE ?

? ?

Frame 30.

We have said that good housekeeping is essential to safe shop operations. Answer these questions.

QUESTIONS 53 through 58.

? ?

53. How should spilled grease or oil on the shop floor be taken care of?

a. Apply absorbent material to the spill and clean it up thoroughly.

b. Wipe it up with a solvent-soaked rag.

c. Flush it down the floor drain.

54. Impact goggles should be worn when

a. working under equipment.

b. doing engine tune-up operations.

c. working in the battery room.

d. sharpening a chisel on a grinder.

55. You must remove all rings and other jewelry when working on any equipment in the maintenance shop.

a. TRUE

b. FALSE

56. Machine guards may be removed or blocked out of the way when they prevent using the machine for special operations.

a. TRUE

b. FALSE

57. All jacks must be equipped with

a. stop chocks.

b. a safety leg or other device which will prevent accidental lowering.

c. side rails.

58. The rated capacity of a jack is

a. the amount of weight the jack will lift and sustain safely.

b. always stamped prominently on the jack except for jacks which come as standard equipment.

c. both "a" and "b" above.

d. neither "a" nor "b."

? ?

Frame 31.

The modern Air Force maintenance shop is equipped with many kinds of power tools to make your job faster and easier. To use these tools requires some knowledge about their safe operation. For example, when using electrical power tools, always make sure that they are grounded. Serious electrical shock could result from using any ungrounded electrically-operated tools.

QUESTION 59.

? ?

? Electrical power tools must be ?

? a. equipped with insulated handles. ?

? b. of the same voltage as the equipment being worked on. ?

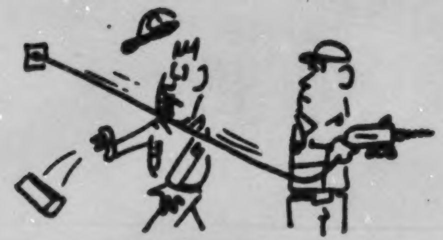
?   ?

? c. grounded. ?

?   ?

? ?

Frame 32.



When using portable electrical tools, it is sometimes necessary to use extension cords or cables. Drop lights are often used in areas which need additional light. An example of this would be when you were working underneath equipment. The mechanic using portable electrical tools and lights will not string cords or cables carelessly across the shop floor. Serious tripping accidents can result.

QUESTION 60.

? ?

When using electrical tools and equipment, you must

a. be sure that they are grounded.

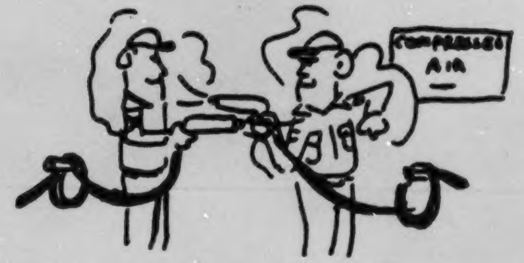
b. not create a hazard with electric cables and cords carelessly strung across the shop.

c. both "a" and "b" above.

d. neither "a" nor "b."

? ?

Frame 33.



Some power tools used in the maintenance shop, such as impact wrenches and air drills, are operated by compressed air. Air may also be used for cleaning debris from a repair job, paint spraying, and airing up tires. Compressed air is dangerous and must be used with caution at all times. It will never be directed at a fellow worker.

QUESTION 61.

? ?

? Compressed air will never be used for ?

? a. cleaning parts. ?

? b. horseplay. ?

? c. both "a" and "b" above. ?

? d. neither "a" nor "b." ?

? ?

Frame 34.

Each mechanic in a maintenance shop will be issued a tool kit for his own personal use. It will be his responsibility to look after these tools and keep them in top shape. Tool kits will be inspected periodically and any defective tools will be replaced immediately. A defective tool could cause serious injury. The Air Force is more than glad to replace your defective tools if doing so will prevent any lost time or injury.

QUESTIONS 62 through 65.

? ?

62. In the interests of safety, tool kits will be

a. turned in for inspection once a month.

b. inspected and defective tools repaired once a week.

c. inspected periodically and defective tools replaced immediately.

63. All electrically-powered equipment and tools must be effectively grounded to prevent electrical shock to the operator.

a. TRUE

b. FALSE

64. Extension cords or cables will not be used with portable electric tools because they are a tripping hazard.

a. TRUE

b. FALSE

65. Defective tools will be replaced immediately.

a. TRUE

b. FALSE

? ?

Frame 36.

One more thing! The maintenance shop is a busy place. Equipment is constantly on the move. All personnel are moving about in the course of their normal duties. To protect personnel, a maximum speed limit of 5 MPH will be enforced in and around the shop. All vehicles entering or leaving the shop will signal with their horn to warn personnel of on-coming traffic.

QUESTIONS 66 and 67.

? ?

66. The maximum speed limit in and around the maintenance shop is

a. 3 MPH.
b. 5 MPH.
c. 10 MPH.

67. When entering or leaving the maintenance shop, vehicle operators must

a. look and proceed with caution.
b. sound horn and proceed with caution.
c. maintain a speed of at least 5 MPH.

? ?

Frame 37.

REMEMBER: It's not enough to just learn the prescribed safety standards, you must also practice them constantly.

If you turned here, looking for the list of correct answers, you will find them printed on the next (last) page.

Frame 38.

Response Confirmation Panel

Question Number	Correct Answers	Question Number	Correct Answers
1.	b.	35.	a.
2.	c.	36.	a.
3.	a.	37.	b.
4.	b.	38.	a.
5.	b.	39.	b.
6.	c.	40.	b.
7.	b.	41.	c.
8.	a.	42.	d.
9.	a.	43.	a.
10.	c.	44.	c.
11.	c.	45.	b.
12.	b.	46.	b.
13.	a.	47.	c.
14.	a.	48.	d.
15.	a.	49.	a.
16.	a.	50.	a.
17.	a.	51.	b.
18.	a.	52.	a.
19.	a.	53.	a.
20.	a.	54.	d.
21.	a.	55.	a.
22.	a.	56.	b.
23.	b.	57.	b.
24.	b.	58.	c.
25.	b.	59.	c.
26.	c.	60.	c.
27.	c.	61.	b.
28.	b.	62.	c.
29.	d.	63.	a.
30.	a.	64.	b.
31.	b.	65.	a.
32.	a.	66.	b.
33.	b.	67.	b.
34.	a.		

106

PREPARE THE MAN

PROGRAMMED TEXT
3ABR47232-PT-101E
3ABR47230-PT-101

Technical Training

8-9

General Purpose Vehicle Mechanic
Base Vehicle Equipment Mechanic

BASIC MATHEMATICS

1 March 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was prepared for use in Course 3ABR47330, Automotive Repairman. The material contained herein was validated with 50 students from the subject course in 1964. The text has been used with approximately 4,000 students and is considered to be still valid.

OBJECTIVES

When you have completed this text, you will be able to accomplish the following objectives with 90% accuracy.

1. Identify the two parts of a given fraction.

2. Identify proper fractions, improper fractions, and mixed numbers from a given list.

3. Change a given list of improper fractions to mixed numbers and mixed numbers to improper fractions.

4. Solve problems in addition and subtraction of fractions.

5. Solve problems in multiplication of fractions, cancelling where applicable.

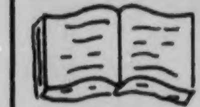
6. Solve problems in division of fractions, cancelling where applicable.

INSTRUCTIONS

In this programmed text you will be given information and then directed to solve problems. The correct answers for the problems will be at the top of the page following the questions. For maximum learning, solve the problem and check it over before looking at the "school solution." If you are in error, go over your work until you find why you were wrong, before preceeding to the next frame.

Supersedes 3ABR47330-PT-101E, 3ABR47231-PT-204, 31 July 1970.
OPR: TWS
DISTRIBUTION: X
TWS - 400; TTVGC - 1

108



We will begin with some simple problems in addition. Add the columns of figures below and record your answers in the proper spaces on your worksheet.

1.	2.	3.	4.
1234	4536	8865	1914
4321	2188	1066	1625
6789	7976	1492	3432
9876	3402	1312	9981
777	211	1945	8005
505	444	9999	803

There! You should be awake by now. Next, let's subtract a few numbers.

5.	6.	7.	8.
987654	382436	6829722	17353
-234567	-365486	-3671594	-9876

Frame 2.

Answers to problems 1 through 8:

1. 23502 2. 18757 3. 25179 4. 25760

5. 753087 6. 16950 7. 3158128 8. 7477

If you missed ANY of these problems, go back over them until you find your mistake.

Let's try a few multiplication problems, now. Enter your answers in the proper spaces on the worksheet. DO NOT work in this program.

9. $\begin{array}{r} 35791 \\ \underline{\times 2432} \end{array}$ 10. $\begin{array}{r} 24680 \\ \underline{\times 1975} \end{array}$ 11. $\begin{array}{r} 1776 \\ \underline{\times 1066} \end{array}$ 12. $\begin{array}{r} 1492 \\ \underline{\times 987} \end{array}$ 13. $\begin{array}{r} 9722 \\ \underline{\times 544} \end{array}$

14. $\begin{array}{r} 77990 \\ \underline{\times 1025} \end{array}$

Now, for a few problems in good ol' division!

15. $\frac{525}{25}$ 16. $\frac{726}{11}$ 17. $28/\overline{1176}$ 18. $341/\overline{162657}$

19. $24/\overline{4872}$

Answers to problems 9 through 19:

9. 87,043,712
10. 48,743,000
11. 1,893,216
12. 1,472,604
13. 5,288,768
14. 79,939,750
15. 21.
16. 66.
17. 42.
18. 477
19. 203

The problems which you have just completed working were somewhat long, but they should not have given you any trouble. Even the division problems had answers in whole numbers. Fractions may prove a bit more difficult, if you have been out of school for a very long time or have forgotten about them. Actually, the same basic arithmetical functions which apply to whole numbers also apply to fractions, but there are some extra steps to take. We will give the rule for performing each function, then work a few problems for practice. A fraction of something is a part of it. If a pie is cut into two equal parts, each of these parts is a fraction of the whole, or in this case, half of it. One half is also written 1/2. Likewise, if the pie were cut into six equal parts, each of the parts would be a fraction of the whole, or one-sixth, also written as 1/6. In any fraction, the number written above the line is called the NUMERATOR. The number below the line is called the DENOMINATOR. This holds true regardless of the size of either number.

PROBLEMS 20 through 22.

? ?

? Write your answers in the proper spaces on your worksheet. ?

? 20. What is the number written above the line in a fraction called? ?

? 21. What is number written below the line called? ?

? 22. If the denominator is twelve and the numerator is five, how would the fraction be written? ?

? ?

Frame 4.

Answers to problems 20 through 22:

20. numerator 21. denominator 22. 5/12

In any fraction, the denominator (number below the line) indicates how many equal parts the whole has been divided into. The numerator indicates how many of these parts are expressed in the fraction. For example, in the fraction 2/5, we know that the whole is divided into 5 parts and 2 of these 5 parts are expressed in the fraction. This rule holds true as long as it is a "proper" fraction, that is, a fraction in which the numerator is a smaller number than the denominator.

QUESTIONS 23 through 25.

? ?

? 23. Define a proper fraction. ?

? 24. Define an improper fraction. ?

? 25. When do you think we would have an improper fraction. ?

? ?

Answers to questions 23, 24, and 25:

23. A proper fraction is one in which the numerator is a smaller number than the denominator.

24. An improper fraction is one in which the numerator is larger than the denominator (naturally).

25. This is MOST likely to occur as the product of an addition or multiplication exercise.

If you do not have these exact words in your answers but the meaning is clear, take credit for correct answers and proceed.

The first function we will take up is addition. In all arithmetical functions with fractions, the first rule to remember is: "The denominators of all fractions to be added, subtracted, multiplied, or divided must be the same." For instance, to add 1/2, 3/4, 5/8, and 3/16, we must first change all the fractions so that they have the same denominator. This is called the "common denominator," since the one number is common to all.

? ?

A common denominator is one into which all of the other numbers will fit without any numbers left over. The first step is to take the largest number in the problem and try to fit all the others into it.

QUESTION 26. What is the common denominator in the above problem.

? ?

Frame 6.

Answer to question 26: 16. This number will contain each of the smaller numbers in the problem (the denominators of each of the fractions). Another way of saying it is that 16 is "divisible" by each of the smaller numbers.

It would be inaccurate to change all of the denominators of the fractions without also changing the numerators, so our problem will now be to add 8/16, 12/16, 10/16, and 3/16. Since the denominator will be the same, we have merely to add the digits in the numerators of the fractions. Such a procedure will give us 33/16. This is an improper fraction, so we will convert it to a proper one by dividing the numerator by the denominator. This gives us a final sum of a and 1/16.

QUESTION 27.

? ?

? Using the system shown above, add 1/2, 2/3, 3/4, and 5/6. ?

? (Remember, you must first find a common denominator. Enter your answer in the proper space on the worksheet.) ?

? ?

? ?

Answer to question 27: 2 and 9/12 or more properly, 2 and 3/4. This demonstrates the second rule which governs the performance of functions with fractions. This rule is: "Always reduce fractions to their lowest terms by dividing both the numerator and denominator by the same number."

This should be a sufficient refresher on the addition of fractions. Next, we will take up the subtraction of fractions. The method of subtracting fractions is quite similar to the method for addition. It is simpler, however, because there can be only two fractions involved in a single problem. The rule for subtracting fractions is: "If the denominators are the same, simply subtract the numerator and reduce the resulting fraction to its lowest terms. If the denominators are not the same, find the lowest common denominator and then subtract the numerator and reduce to the lowest terms.

EXAMPLE: 9/16 - 5/16 = 4/16, or reduced to lowest terms, 1/4.
9/16 - 3/8 = 9/16 - 6/16 = 3/16 (cannot be reduced).

PROBLEMS 28 through 32.

? ?

? Using the information above, work the following problems and enter ?
your answers in the proper spaces on the worksheet.
? ?

	28.	29.	30.	31.	32.	
	3/4	5/6	5/6	7/8	7/8	
?	-1/4	-1/6	-1/3	-23/32	-11/64	?

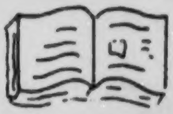
? ?

Frame 8.

Answers to problems 28 through 32:

28. 1/2 29. 2/3 30. 1/2 31. 5/32 32. 45/64

You will note that all of the answers have been reduced to their lowest terms.



A mixed number is composed of both a whole number and a fraction, such as 2 & 1/3. At times, there is an advantage to converting a mixed number to an improper fraction, to facilitate addition, subtraction, multiplication, or division of fractions. This is accomplished by simply multiplying the whole number by the denominator of the fraction, adding the numerator to this product, and entering the sum of these two numbers above the denominator. For example: to convert 5 3/8 to an improper fraction, we multiply 5 x 8 = 40, +3 = 43/8. Thus, if we were to add 5 3/8, 2 1/4, and 6 1/2, the problem would look like this: 5 3/8 + 2 1/4 + 6 1/2 = 43/8 + 9/4 + 13/2. Since we must find the lowest common denominator and convert all elements of the problem, it would now be 43/8 + 18/8 + 52/8. We now add the numerators, and the answer becomes 113/8. When we reconvert to a mixed number, we divide the numerator by the denominator, or

$$\begin{array}{r} 14 \\ 8\,\overline{)\,113} \\ \underline{8} \\ 33 \\ \underline{32} \\ 1 \end{array}$$

Since there is 1 left over. we say that the answer is 14 1/8.

PROBLEM 33.

? ?

? Add the following mixed numbers, as shown above, and enter your ?
answer in the proper space on your worksheet.
? ?

3 1/8 + 4 3/4 + 2 1/2 + 6 3/16 = ?
? ?

? ?

The answer to problem 33 is: 16 9/16. (9/16 cannot be reduced)

Since this Program is designed as a refresher, rather than as a lesson which presents a lot of new material, we will not dwell at great length on the practicing or repetition of each segment. If you find any portion to be difficult, repeat that portion until you are sure of yourself before going on to the next frame. We have covered the addition and subtraction of fractions, and the conversion of fractions to mixed numbers and vice-versa. Next we will take up multiplication of fractions. The first rule of multiplication of fractions is: "Any number multiplied by a proper fraction will yield a smaller number than the original." For instance, 1/2 of 100 is 50; 9/10 of 100 is 90. Multiplication of fractions is relatively simple. The numerators are multiplied, and the product is entered above the the line as a whole number. Then the denominators are multiplied and the product is entered below the line as a whole number. For example: 1/4 x 2/3 = 2/12 (or, reduced, 1/6). Likewise, 1/3 x 1/5 = 1/15.

PROBLEMS 34 through 39.

? ?

34. 3/5 x 1/3

35. 3/4 x 1/3

36. 3/8 x 2/3

37. 1/5 x 1/4

38. 2/5 x 1/4

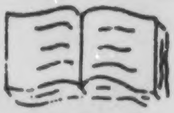
39. 1/6 x 2/3

? ?

Frame 10.

Correct answers for problems 34 through 39 are:

34. 3/15 (1/5)   35. 3/12 (1/4)   36. 6/24 (1/4)
37. 1/20   38. 1/10   39. 1/9



The procedure for multiplying improper fractions or mixed numbers is the same, exrept that in the case of mixed numbers they must first be changed to improper fractions before multiplying. For example: to multiply 2 1/3 x 3 1/4, you would write the problem:

7/3 x 13/4 = 91/12, or 7 7/12.

PROBLEMS 40 through 44.

? ?

? Using the information above, multiply the following mixed numbers ?
and enter the answers in the proper spaces on your worksheet.

? ?

? 40. 3 1/4 x 2 1/3   41. 4 1/3 x 3 3/5   42. 6 1/2 x 2 1/3   43. 5 3/8 x 2 1/2   44. 7 2/3 x 3 1/4 ?

? ?

? ?

Frame 11.

The correct answers for problems 40 through 44 are:

40. 7 7/12 41. 15 3/5 42. 15 1/6 43. 13 7/16 44. 24 11/12

The multiplication problems we have worked have had only two fractions in each problem. However, any number of fractions may be multiplied at the same time. Simply multiply the numerators together and the denominators together, changing mixed numbers to improper fractions when necessary. Whole numbers are shown as improper fractions with a denominator of 1. The last arithmetic exercise with fractions which we will take up is division. This is quite simple to accomplish, since the only difference between division and multiplication is that we invert the divisor. For example: if we want to divide 1/5 by 1/3, we simply invert the divisor, 1/3. and multiply:

$$1/5 \div 1/3 = 1/5 \times 3/1 = 3/5.$$

PROBLEMS 45 through 48.

? ?

? Using the information above, work the following problems in division?
and record your answers in the proper spaces on your worksheet.
? ?
45. 3/8 ÷ 3/4 46. 2 1/3 ÷ 2/3 47. 2/3 ÷ 3/4
? ?
43. 3 5/8 ÷ 1 2/3
? ?

? ?

Frame 12.

The correct answers for problems 45 through 48 are:

45. 1/2 46. 3 1/2 47. 8/9 48. 2 7/40

This should be sufficient review in all arithmetic functions of fractions. We will now take up the writing of decimals from narrative descriptions. To understand decimals, we must first realize that the entire system consists of multiples of ten. Whole numbers are always shown to the left of the period or decimal point. Parts of numbers are shown to the right of the decimal point. The first place after the decimal is occupied by tenths. The first multiple of ten is one-hundred, or hundredth. The second place after the decimal is thus occupied by hundredths. The next multiple of ten is thousandths, and this occupies the third place after the decimal. In like manner, the fourth place is occupied by ten-thousandths, the fifth place by hundred-thousandths, and the sixth place by millionths, since a million is 1,000 times 1,000. Therefore, a narrative description which reads "six and seven-tenths" would appear as 6.7, and a temperature reading of ninety-eight and six-tenths would be 98.6.

PROBLEMS 49 through 52.

? ?

? Using the information above, convert the following narrative descriptions to decimal figures and enter the answers in the proper spaces on your worksheet. ?

? 49. "The outside temperature is ninety-one and seven-tenths degrees." ?

? 50. "The barometer indicates twenty-nine and thirty-nine hundredths." ?

? 51. "The clearance is seven-thousandths of an inch." ?

52. "The tolerance is plus or minus fifteen-thousandths."

? ?

The correct answers for problems 49 through 52 are:

49. 91.7 50. 29.39 51. .007 52. ± .015

Since you will be working primarily with clearances, tolerances. etc. you will find most values expressed in thousandths, since the thickness or "feeler" gauge, micrometer, and all other accurate instruments are graduated in thousandths. Thus, .0015 is fifteen ten-thousandths, but mechanics often express it as "one and one-half thousandths."

The writing of decimals becomes automatic IF we just remember that the decimals are the multiples of ten. We will convert some decimals to fractions next, then convert some fractions to decimals. A decimal is really a fraction except that only the numerator is shown. following a period, or "decimal point." The denominator of the fraction is determined by how many places are shown in the decimal. For instance, we already learned that the first place to the right of the decimal point is for tenths, the second for hundredths. the third for thousandths, etc. Thus, .7 would be seven-tenths, or 7/10, but the exact same value, if written .700, would read seven hundred thousandths, or 700/1,000. Even though the zeros do not change the value, most of your work will be expressed in this manner.

PROBLEMS 53 through 57.

? ?

? Using the information above. convert the following decimals to ?
fractions and enter your answers in the proper spaces on the worksheet.
? ?
53. .700 54. .0015 55. .090 56. .0005
? ?
57. 3.014
? ?

? ?

Frame 14.

The correct answers for problems 53 through 57 are:

53. 700/1,000 54. 15/10,000 55. 90/1,000

56. 5/10,000

57. 3 14/1,000

Converting a fraction to a decimal is accomplished by simply dividing the numerator of the fraction by the denominator. One of the things to remember is that in a proper fraction (one in which the numerator is smaller than the denominator), the answer, or "quotient", will be less than 1. In other words, the complete answer will be to the right of the decimal point. Because we are nearly always dealing in thousandths, we will automatically carry the answer to three places. For example: 1/2 inch is converted as follows:

$$2\,\overline{)\,1.000}^{\;.500} \text{ inch}$$

3/4 becomes

$$\begin{array}{r} .750 \\ 4\,\overline{)\,3.000} \\ \underline{2\,8} \\ 20 \\ \underline{20} \end{array}$$

The extra zero is added in order to give the required three decimal places in the answer.

PROBLEMS 58 through 63.

? ?

Using the information above, convert the following fractions to decimals, and enter your answers in the proper spaces on your worksheet.

58. 5/8 59. 2/3 60. 3/16 61. 5/32 62. 2/5

63. 7/16

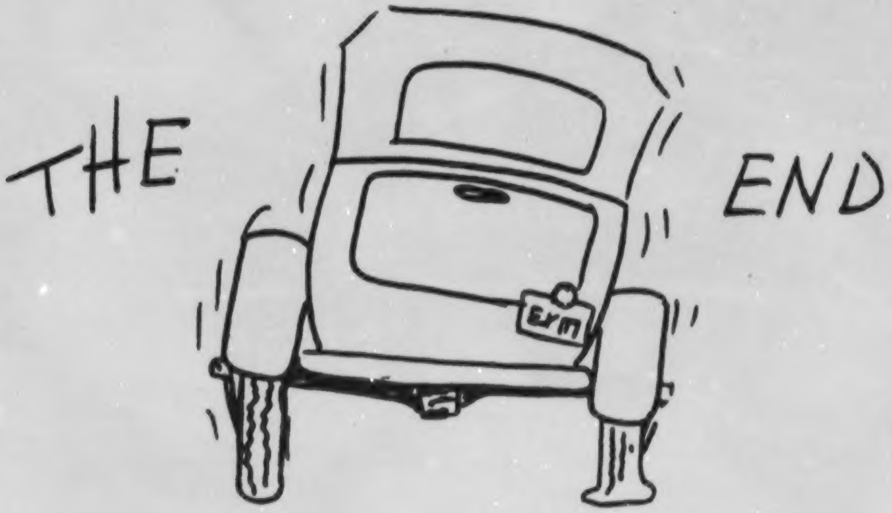
? ?

Answers to problems 58 through 63 are:

58. .625   59. .666   60. .1875   61. .156   62. .400
63. .4375

The instructions said: "Carry the quotient three places only." When the fourth place has a number "5" or below, the three places do not change. When the fourth place is larger than "5," one number is added to the figure which occupies the third place. Thus, problem 59 would be more accurately answered as .667.

You have now completed the "Math Refresher Program." As we stated, no attempt was made to present new material, but only to review. If you were hazy in any of the areas, it will be helpful for you to take a few minutes right now and go over these areas again. On the other hand, if you feel that you are properly "refreshed," notify your instructor.



FACTIONAL / DECIMAL EQUIVALENTS

Fraction	Decimal
1/64	.015625
1/32	.03125
3/64	.046875
1/16	.0625
5/64	.078125
3/32	.09375
7/64	.109375
1/8	.125
9/64	.140625
5/32	.15625
11/64	.171875
3/16	.1875
13/64	.203125
7/32	.21875
15/64	.234375
1/4	.250
17/64	.265625
9/32	.28125
19/64	.296875
5/16	.3125
21/64	.328125
11/32	.34375
23/64	.359375
3/8	.375
25/64	.390625
13/32	.40625
27/64	.421875
7/16	.4375
29/64	.453125
15/32	.46875
31/64	.484375
1/2	.500

Fraction	Decimal
33/64	.515625
17/32	.53125
35/64	.546875
9/16	.5625
37/64	.578125
19/32	.59375
39/64	.609375
5/8	.625
41/64	.640625
21/32	.65625
43/64	.671875
11/16	.6875
45/64	.703125
23/32	.71875
47/64	.734375
3/4	.750
49/64	.765625
25/32	.78125
51/64	.796875
13/16	.8125
53/64	.828125
27/32	.84375
55/64	.859375
7/8	.875
57/64	.890625
29/32	.90625
59/64	.921875
15/16	.9375
61/64	.953125
31/32	.96875
63/64	.984375

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~232-PT-107B
3ABR47231-PT-205

Technical Training

8-9

General Purpose Vehicle Repairman
Special Vehicle Repairman

AUTOMOTIVE TERMINOLOGY AND HARDWARE

30 July 1970

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-107B, 1 October 1969.
OPR: TSDT
DISTRIBUTION: X
TSDT - 500; TSOC - 3

Designed For ATC Course Use

FOREWORD

This Programmed Text was prepared for use in 3ABR47330, Automotive Repairman's course by the Instructional Systems Development Team. The text was validated in 1964, using 100 students from the subject course. At least 90% of the students achieved the objectives as stated. This text has been used to train at least 3,000 students, and is considered valid.

OBJECTIVES

When you have completed this text, you will be able to:

1. Define an internal combustion engine.
2. Identify the major components of an automotive vehicle, with 70% accuracy.
3. State the purpose of the components of the major systems of a vehicle, with 70% accuracy.
4. Identify the types of hardware used in automotive vehicles, with 70% accuracy.
5. Identify the tool used to measure the threads of fastening devices.

INSTRUCTIONS

This program presents information in small steps called "frames." After each step (frame) you are asked to select a correct statement. Use a piece of paper or card as a mask over the material. Slide this mask down the page until you expose the top of a short line of slashes (////////////////). Read the material presented and mark your choice of statements by circling the appropriate letter or number in the frame. For matching type questions or for statements, the answer will be written in the space provided in the frame. After you have marked your answer, slide the mask down until the answer space is exposed. Check your answer against the correct one given. If you are correct, go on to the next frame. If you are incorrect, read the frame again and reason out the correct statement or answer.

There is no time limit on this program. Take your time and follow the instructions in each frame carefully.

Internal combustion engines are those which burn fuel inside themselves to produce power. Which of the following power plants would be an internal combustion type?

a. Automobile engine.

b. Steam engine.

c. Electric motor.

d. Motor-generator.

//////////////////////////////////

a.

2.

Automobiles have a power plant designed for

a. internal combustion.

b. external combustion.

c. steam power.

d. electric power.

//////////////////////////////////

a.

3.

You, as a motor vehicle mechanic, will be concerned with several types and makes of engines. One of the things you will be concerned with is the fact that automobile engines make 4 strokes to complete one cycle. The type power plant that you will be repairing will be an

a. internal combustion 1 stroke cycle engine.

b. internal combustion 4 stroke cycle engine.

c. external combustion 1 stroke cycle engine.

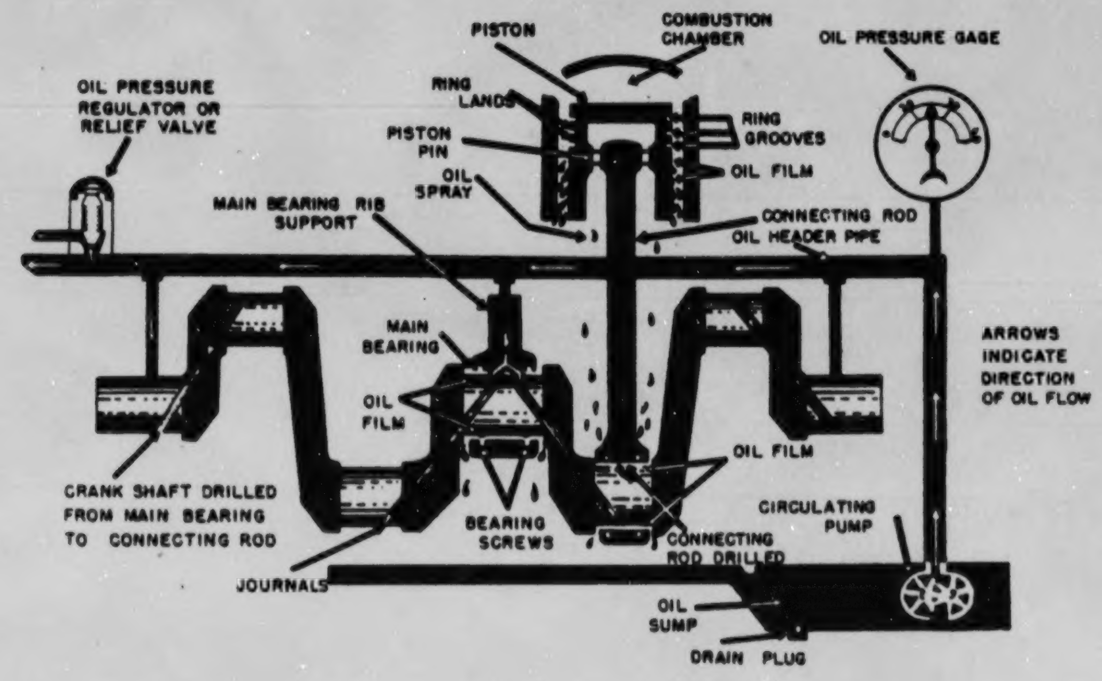
d. external combustion 4 stroke cycle engine.

//////////////////////////////////

b.

4.

The diagram below is that of a lubrication system. Note in the diagram that oil is picked up by the pump and delivered throughout the engine to help prevent friction, and to help cool some of the engine parts. Study this diagram carefully.


PISTON
COMBUSTION CHAMBER
OIL PRESSURE GAGE
RING LANDS
OIL PRESSURE REGULATOR OR RELIEF VALVE
PISTON PIN
RING GROOVES
OIL FILM
OIL SPRAY
MAIN BEARING RIB SUPPORT
CONNECTING ROD
OIL HEADER PIPE
MAIN BEARING
ARROWS INDICATE DIRECTION OF OIL FLOW
OIL FILM
OIL FILM
CRANK SHAFT DRILLED FROM MAIN BEARING TO CONNECTING ROD
CIRCULATING PUMP
BEARING SCREWS
CONNECTING ROD DRILLED
JOURNALS
OIL SUMP
DRAIN PLUG

////////////////////////////////

No response was called for.
Go to the next frame.

5.

The system that provides lubrication, aids in cooling engine parts, and helps to prevent friction is the

a. cooling system.

b. ignition system.

c. lubrication system.

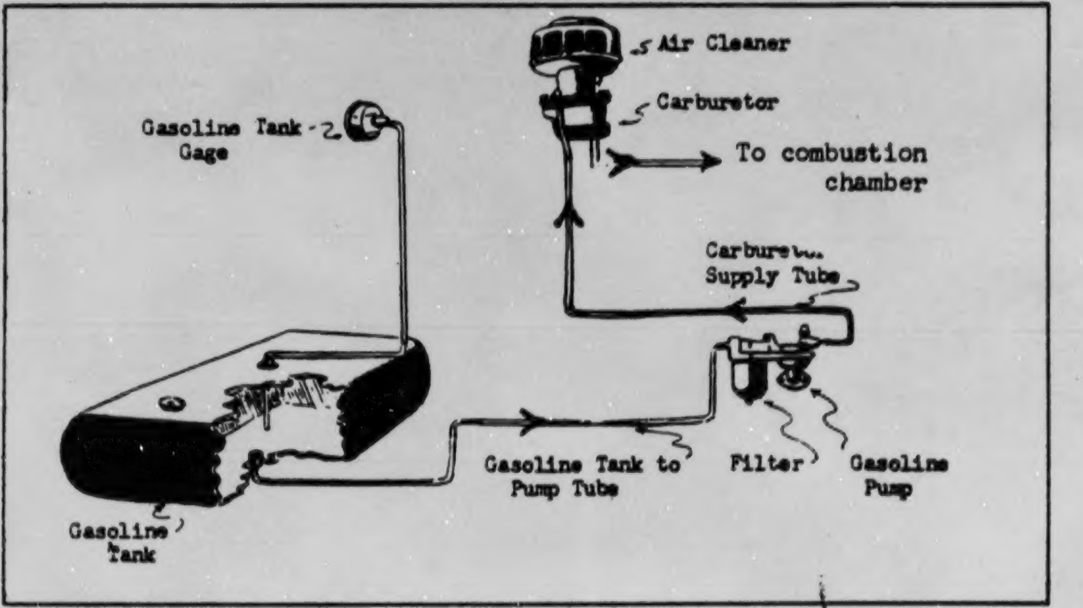
d. fuel system.

////////////////////////////////

c.

6.

As we have previously discussed, all internal combustion engines burn fuel inside themselves to produce power. Using the fuel systems diagram below, start with the gasoline storage tank and trace the route which the fuel travels. Then, select the correct statement.


Air Cleaner
Carburetor
Gasoline Tank Gage
To combustion chamber
Carburetor Supply Tube
Gasoline Tank to Pump Tube
Filter
Gasoline Pump
Gasoline Tank

a. The fuel stops at the carburetor.

b. The fuel is consumed in the combustion chambers.

c. The fuel pump does not allow fuel to go to the carburetor.

d. The air cleaner filters the fuel.

////////////////////////////////

b.

7.

The system responsible for delivering fuel to the engine combustion chamber is the

a. fuel/air mixture system.

b. carburetion system.

c. fuel system.

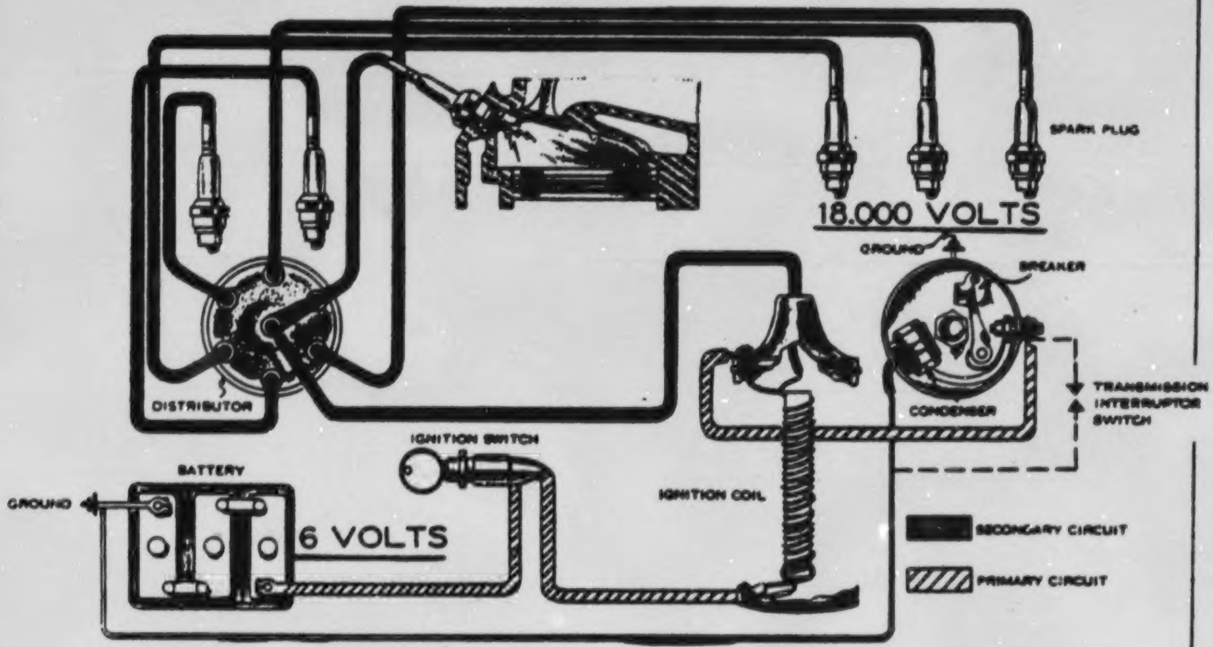
d. fuel/air filtering system.

////////////////////////////////

c.

8.

The diagram below shows fuel being ignited in the combustion chamber as a result of the operation of a complete system. The current for this ignition is provided by a battery through a series of coils, condensors, wiring, and spark plugs. Observe that a tremendous amount of voltage is required to ignite the fuel. Start with the battery and trace the wiring to the combustion chamber. Then, select the correct statement.


SPARK PLUG
18.000 VOLTS
GROUND
BREAKER
TRANSMISSION INTERRUPTOR SWITCH
CONDENSER
DISTRIBUTOR
IGNITION SWITCH
BATTERY
GROUND
6 VOLTS
IGNITION COIL
SECONDARY CIRCUIT
PRIMARY CIRCUIT

The system that ignites the fuel/air mixture in the combustion chamber is the

a. ignition system.

b. electrical system.

c. spark plug system.

d. ignition coil system.

////////////////////////////////

a.

9.

Igniting the fuel/air mixture at a pre-determined time with a pre-determined amount of voltage is the function of the

a. alternating current system.

b. direct current system.

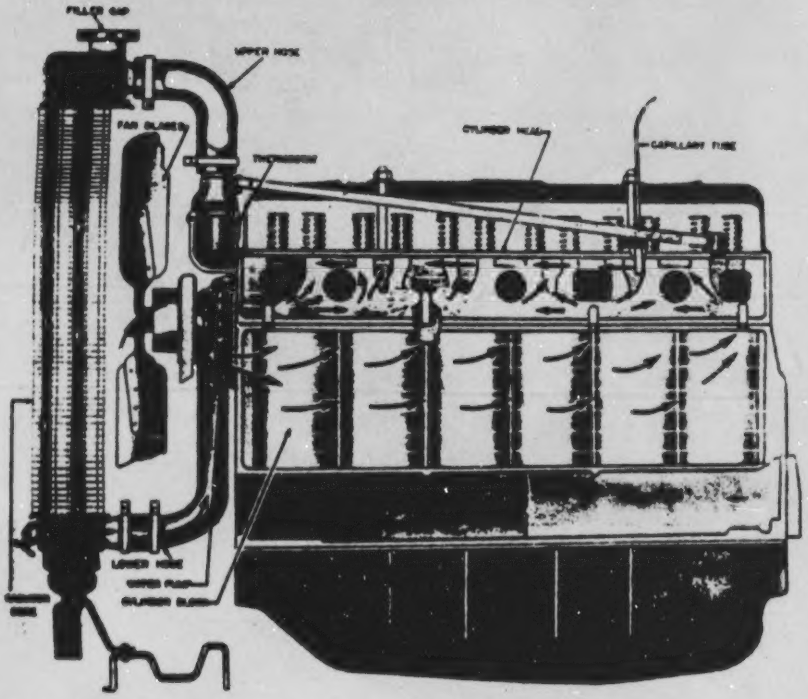
c. ignition system.

d. electrical system.

////////////////////////////////

10.

In the diagram below, note how the water, which is represented by the arrows, circulates throughout the entire engine system. The purpose of this system is to keep an engine operating at its most efficient temperature under all load conditions.


FILLER CAP
UPPER HOSE
FAN BLADES
THERMOSTAT
CYLINDER HEAD
CAPILLARY TUBE
LOWER HOSE
WATER PUMP
CYLINDER BLOCK

This system is called the engine

a. heating system.

b. cooling system.

c. water pump system.

d. radiator system.

//////////////////////////////////

b.

11.

The purpose of the engine cooling system is to

a. allow the engine to operate at its most efficient temperature under all load conditions.

b. keep the engine from ever getting warm.

c. keep the engine from getting too cold.

d. cool the engine only when it is under a great load in extremely hot weather.

////////////////////////////////

a.

12.

Motor vehicle power plants are made up of several different systems. The basic systems deliver the proper fuel/air mixture from the fuel supply tank to the combustion chamber of an engine, ignite the fuel at a pre-determined time with the required amount of voltage, properly oil all the moving parts of the engine, and keep the engine at its most efficient temperature under all load conditions. These four systems are commonly referred to as the

a. ignition, fuel, lubrication, and brake systems.

b. ignition, fuel, lubrication, and cooling systems.

c. ignition, fuel, electrical, and cooling systems.

d. ignition, electrical, temperature, and fuel/air systems.

////////////////////////////////

b.

13.

The ignition, fuel, lubrication, and cooling systems are the basic systems of the vehicle

a. power train.

b. operating systems.

c. power plant.

d. power systems.

////////////////////////////////

c.

Continue on next page.

Figure 1 (below) is a partial cutaway of a typical V-8 engine equipp with its basic systems. Figure 2 is a picture of a 6 cylinder engine, a on which you will be frequently required to perform maintenance. Study th pictures so you will become familiar with these types of engines.

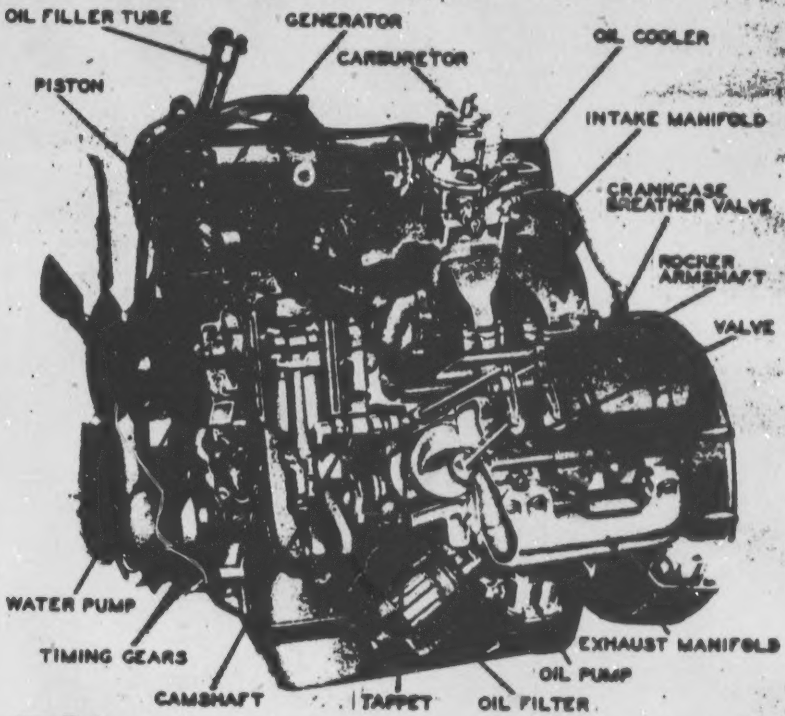
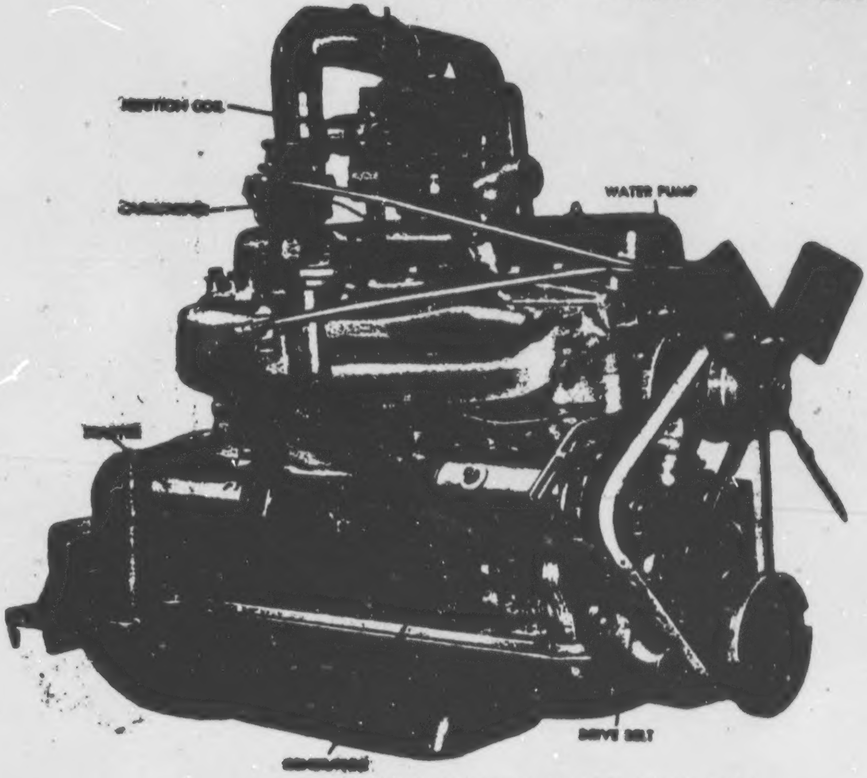

OIL FILLER TUBE
GENERATOR
CARBURETOR
OIL COOLER
PISTON
INTAKE MANIFOLD
CRANKCASE BREATHER VALVE
ROCKER ARMSHAFT
VALVE
WATER PUMP
TIMING GEARS
CAMSHAFT
TAPPET
OIL FILTER
OIL PUMP
EXHAUST MANIFOLD

Figure 1— — —


IGNITION COIL
WATER PUMP
DRIVE BELT

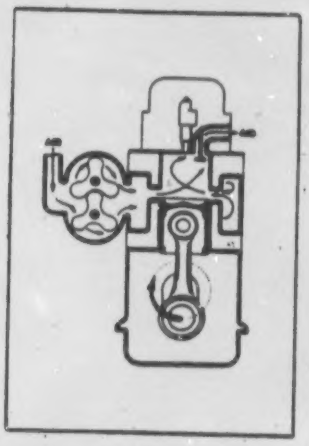
— — - Figure 2

///////////////////////////////////////

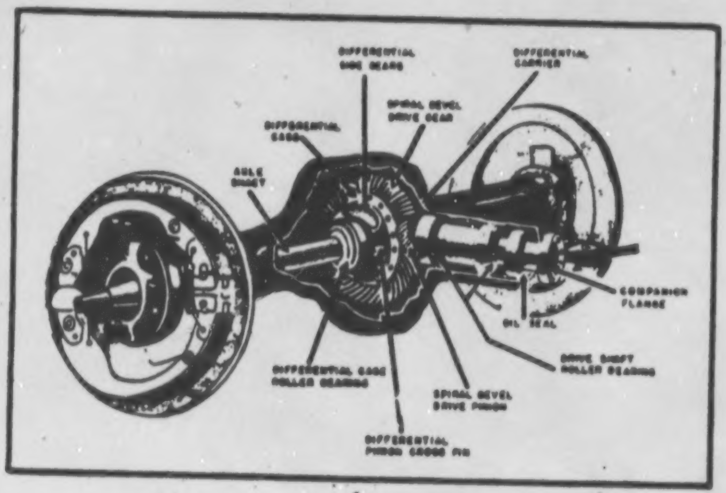
Go on to the next frame.
No response required.

15.

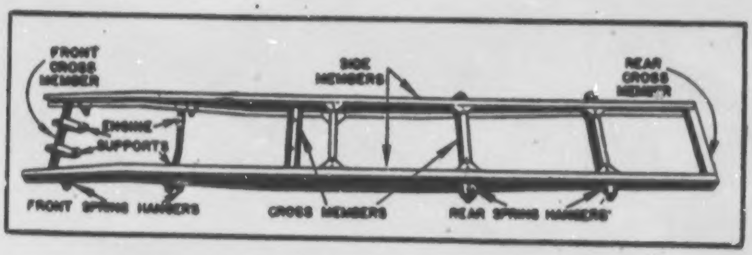
The frame of a vehicle is constructed of channel or "U" shaped steel that must be strong enough to support all the vehicle components. Which of the diagrams below is that of a vehicle frame?



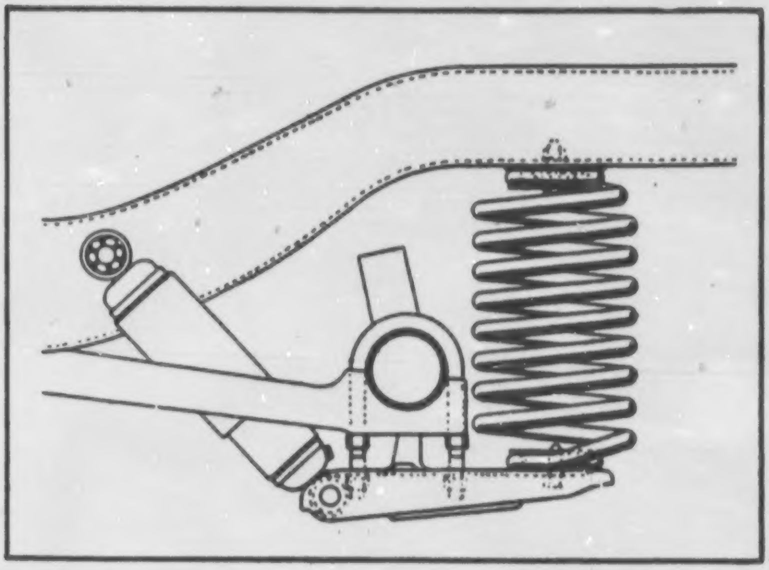
a. ___


DIFFERENTIAL SIDE GEARS
DIFFERENTIAL CARRIER
SPIRAL BEVEL DRIVE GEAR
DIFFERENTIAL CASE
AXLE SHAFT
COMPANION FLANGE
OIL SEAL
DRIVE SHAFT ROLLER BEARING
DIFFERENTIAL CASE ROLLER BEARING
SPIRAL BEVEL DRIVE PINION
DIFFERENTIAL PINION CROSS PIN

b. ___


FRONT CROSS MEMBER
SIDE MEMBERS
REAR CROSS MEMBER
ENGINE SUPPORTS
FRONT SPRING HANGERS
CROSS MEMBERS
REAR SPRING HANGERS

c. ___



d. ___

//

c.

16.

Because a vehicle is subjected to twisting, vibrations, and road shocks, the frame must be very strong. Frames are normally constructed of

a. angle iron.

b. spring type steel.

c. channel or "U" shaped steel.

d. cast iron.

////////////////////////////////

c.

17.

Vehicle frames are constructed of channel or "U" shaped steel and while supporting the weight of the vehicle they are designed to

a. absorb road shock and withstand vibration and twisting.

b. enclose the passenger and cargo compartments.

c. create vehicle design and styling.

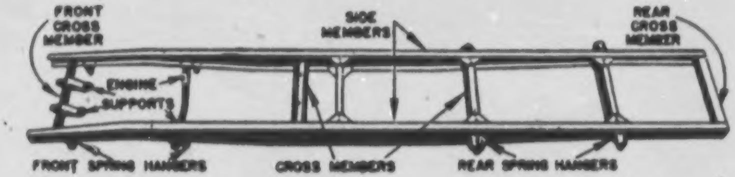
d. provide a rigid, non-flexible platform for the vehicle components.

////////////////////////////////

a.

18.

In the diagram below, note the engine supports and how the channel or "U" shaped frame material is responsible for supporting the engine weight.

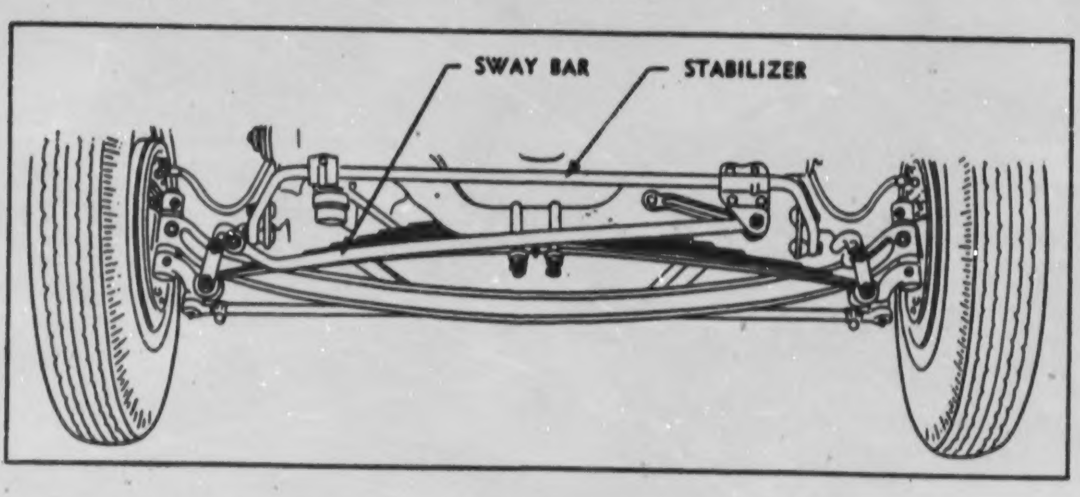

FRONT CROSS MEMBER
SIDE MEMBERS
REAR CROSS MEMBER
ENGINE SUPPORTS
FRONT SPRING HANGERS
CROSS MEMBERS
REAR SPRING HANGERS

////////////////////////////////

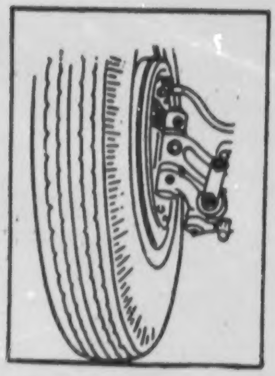
Go to the next frame.
No response required here.

19.

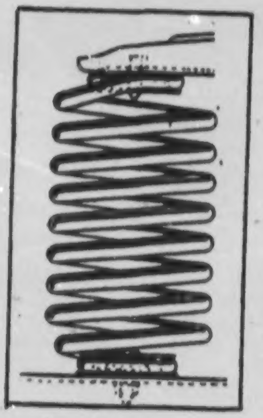
A vehicle's suspension system has springs which are of either the coil or leaf type. A coil spring is spiral shaped and constructed of spring steel. The leaf spring is one or more pieces of flat spring steel in varying lengths which are bolted or clamped together. Place a check by the diagrams below which illustrate coil or leaf springs.



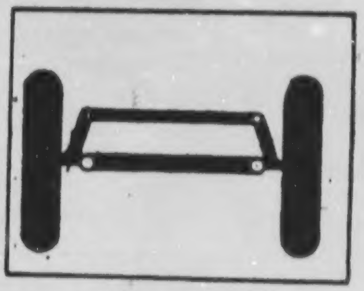
a. ___



b. ___



c. ___

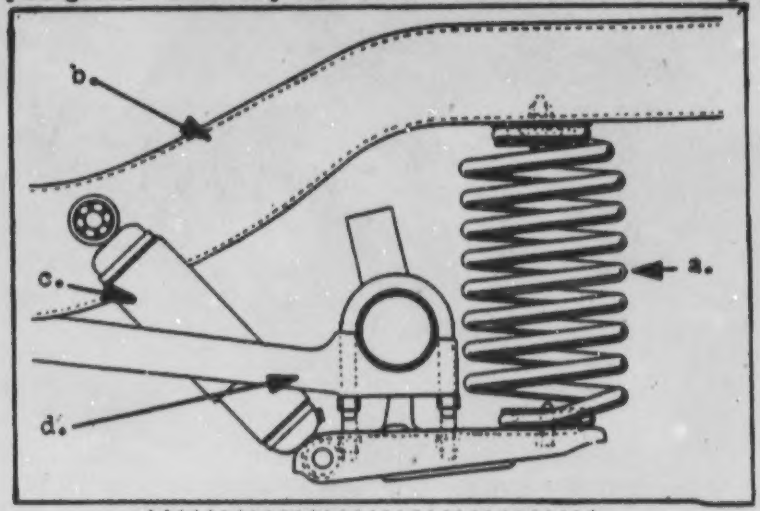


d. ___

//////////////////////////////

a. & c.

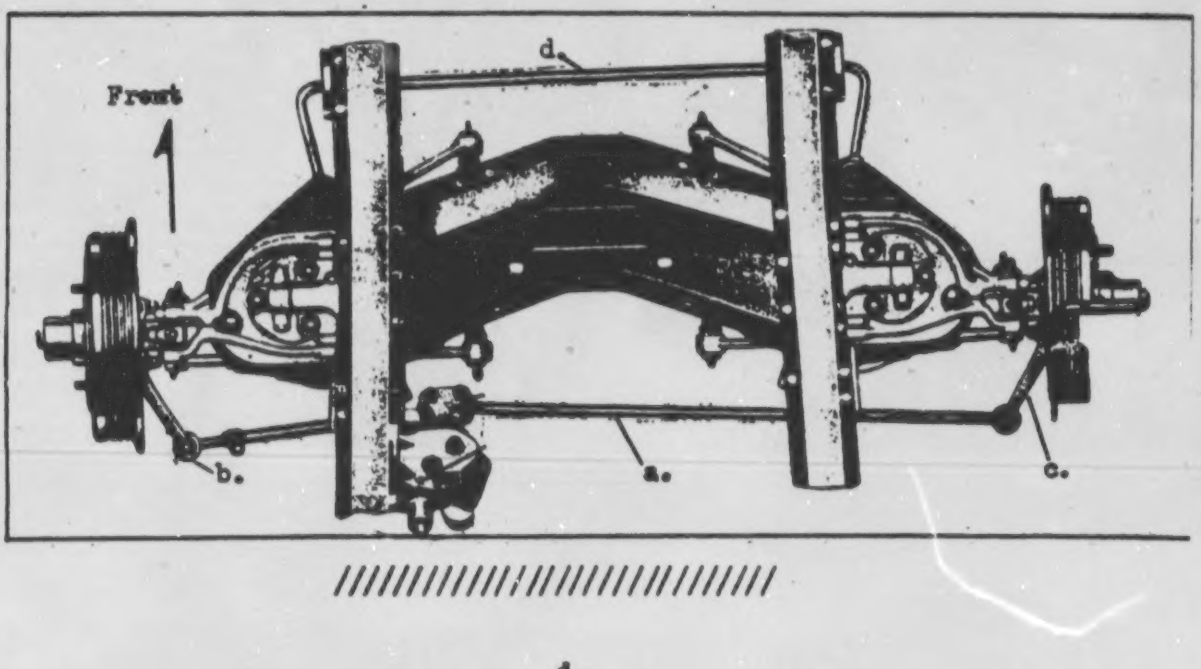
Regulating spring rebound and compression is the function of a shock absorber, which is a part of the vehicle suspension system. Shock absorbers are generally cylindrical, and are equipped with an assembly of valves, springs, and plungers. Identify the shock absorber in the diagram below.



c.

21.

Stabilizer bars, which keep a vehicle from swaying, are connected to the front wheel suspension assembly and the front of the vehicle frame. In the diagram below, identify the stabilizer bar.



d.

22.

The vehicle suspension system consists of

a. frame, springs, and shock absorbers.

b. springs, steering apparatus, frame, and torsion bar.

c. sway bar, torsion bar, frame, and stabilizer.

d. springs, shock absorbers, and stabilizer bar.

////////////////////////////////

d.

23.

Springs help support the weight of a vehicle, shock absorbers regulate the spring rebound and compression, and stabilizer bars keep the vehicle from swaying excessively. These components make up the suspension system of a vehicle and collectively are designed to

a. connect the front wheels to the frame.

b. permit the operator to have directional control of the vehicle.

c. stabilize the vehicle and aid in steering.

d. keep the vehicle in level position regardless of load condition.

////////////////////////////////

c.

24.

In order for a vehicle operator to have directional control over a vehicle it is necessary to have a

a. steering system.

b. suspension system.

c. power train.

d. well-aligned frame.

////////////////////////////////

a.

138

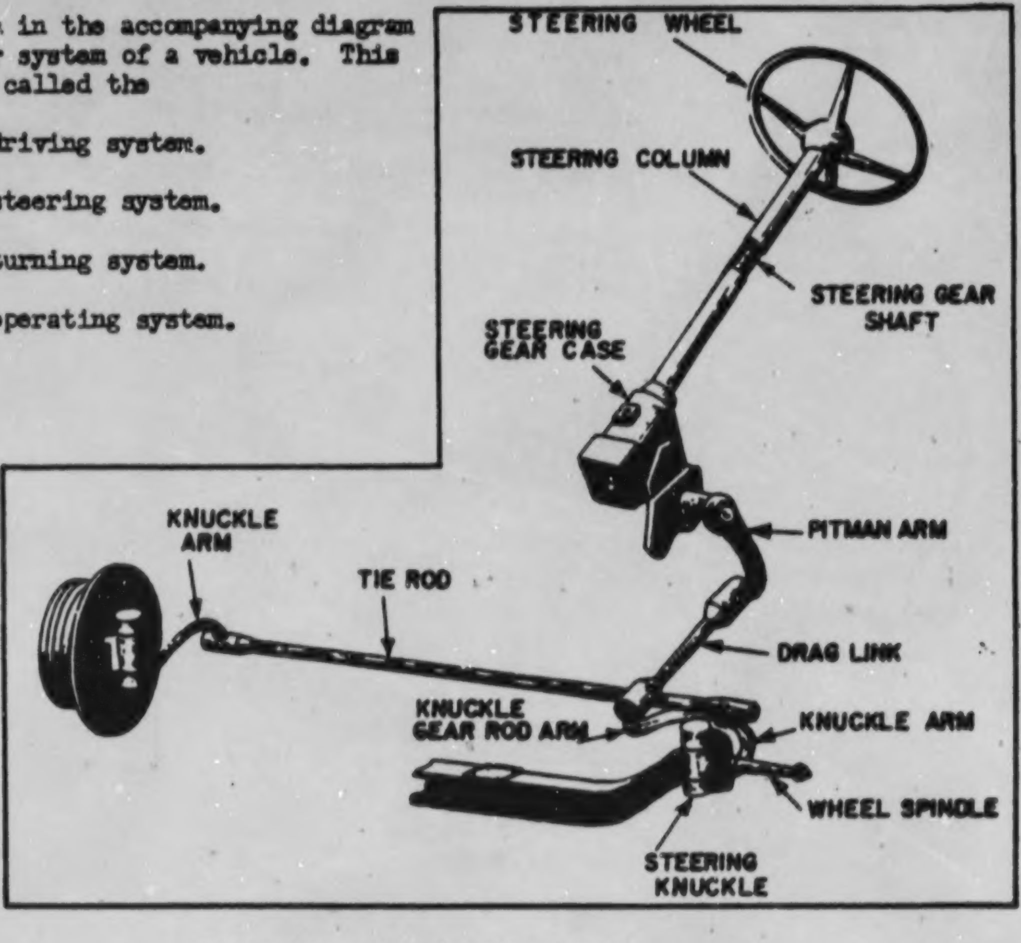
Shown in the accompanying diagram is another system of a vehicle. This system is called the

a. driving system.

b. steering system.

c. turning system.

d. operating system.


STEERING WHEEL
STEERING COLUMN
STEERING GEAR SHAFT
STEERING GEAR CASE
PITMAN ARM
KNUCKLE ARM
TIE ROD
DRAG LINK
KNUCKLE GEAR ROD ARM
KNUCKLE ARM
WHEEL SPINDLE
STEERING KNUCKLE

////////////////////////////////

b.

26.

The operator must have directional control over his vehicle at all times. The system which permits this directional control is the

a. suspension system.

b. power system.

c. steering system.

d. lighting system.

////////////////////////////////

c.

27.

The purpose of the vehicle steering system is to

a. permit the operator to have stabilizing control over the vehicle.

b. stabilize the vehicle under varying load conditions.

c. permit the vehicle to adapt to road conditions.

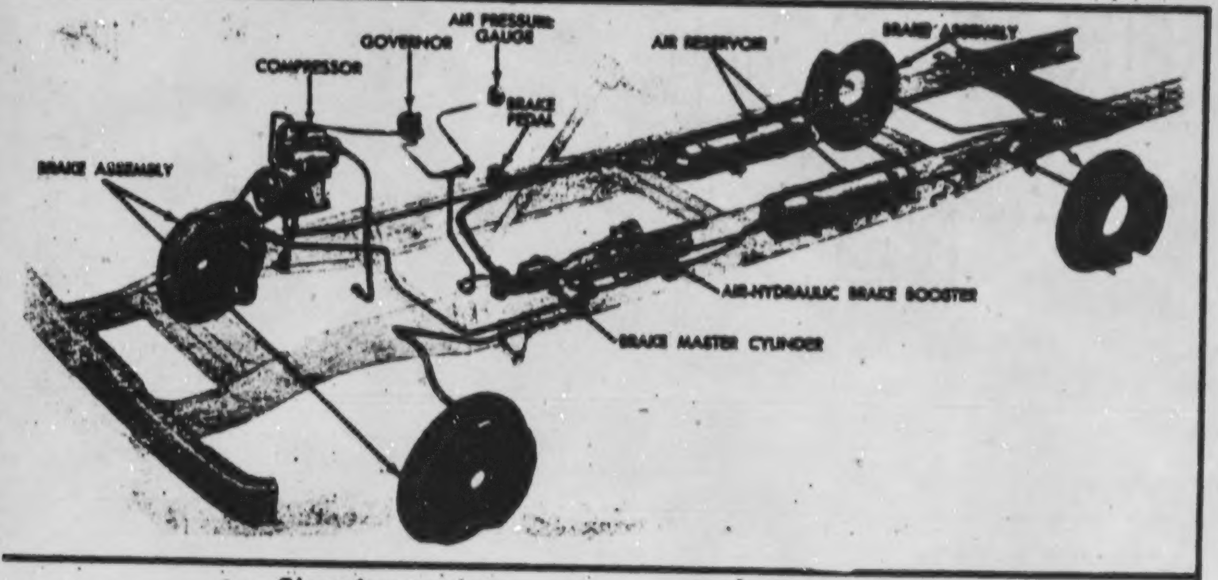
d. permit the operator to have directional control over the vehicle.

//////////////////////////////////

d.

28.

The diagram below depicts still another system of a vehicle. Which vehicle system does it show?


AIR PRESSURE GAUGE
GOVERNOR
COMPRESSOR
AIR RESERVOIR
BRAKE ASSEMBLY
BRAKE PEDAL
BRAKE ASSEMBLY
AIR-HYDRAULIC BRAKE BOOSTER
BRAKE MASTER CYLINDER

a. Steering system.

b. Brake system.

c. Suspension system.

d. Drive system.

//////////////////////////////////

b.

So that the vehicle operator may have control over the slowing or stopping of a vehicle, it is equipped with a

a. suspension system.

b. steering system.

c. engine system.

d. brake system.

//////////////////////////////////

d.

30.

Although there are many types, all brake systems are designed to

a. slow or stop a moving vehicle.

b. help steer a vehicle.

c. aid in vehicle suspension.

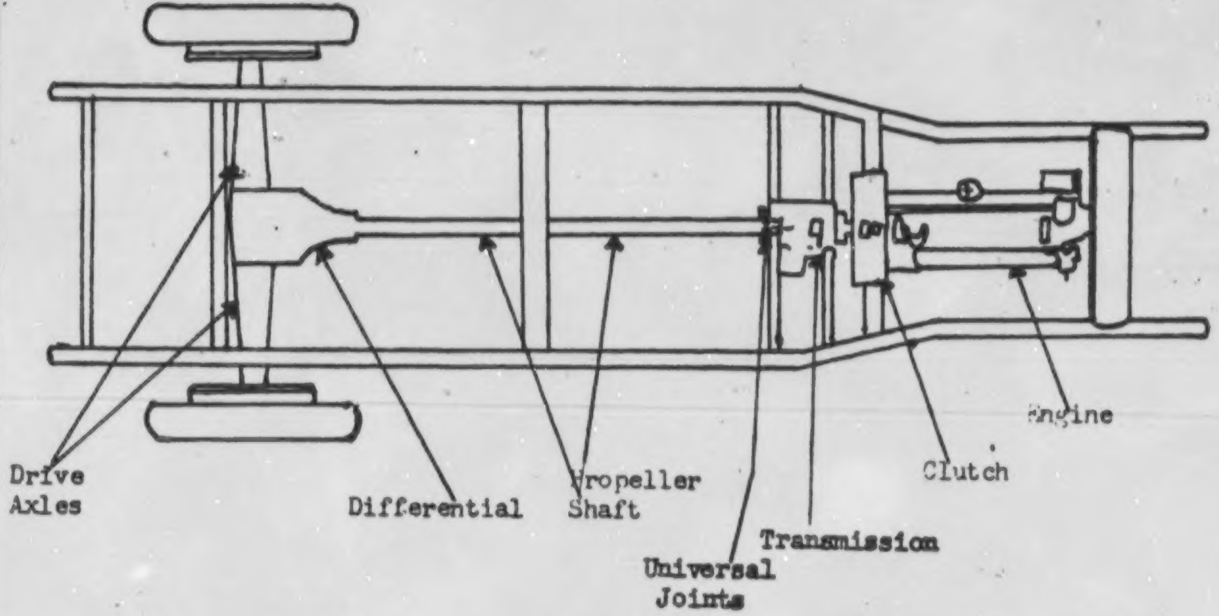
d. stabilize a vehicle in motion.

//////////////////////////////////

a.

31.

To acquaint you with the major components of a power train, study the diagram below to see how all components fit together. Notice particularily, how all the components are connected in series from the engine all the way to the driving axles.


Engine
Clutch
Drive Axles
Differential
Propeller Shaft
Transmission
Universal Joints

//////////////////////////////////

Go to the next frame.
No response required here.

32.

The clutch in a vehicle's power train is a friction type connection between the engine and the transmission. The purpose of the clutch is to connect

a. or disconnect the engine to or from the differential.

b. the propeller shaft to or from the differential.

c. or disconnect the transmission to or from the differential.

d. or disconnect the engine to or from the transmission.

////////////////////////////////

d.

33.

Since the clutch in a vehicle's power train is used to connect and disconnect the engine from the transmission, it must be located between the

a. transmission and differential.

b. engine and transmission.

c. transmission and propeller shaft.

d. propeller shaft and the differential.

////////////////////////////////

b.

34.

The part of the vehicle's power train that is designed to connect or disconnect the transmission from the engine is the

a. differential.

b. transmission.

c. clutch.

d. propeller shaft.

////////////////////////////////

c.

35.

When the clutch is engaged by the vehicle operator a combination of gears are set in motion. These gears are called the

a. transmission.

b. differential.

c. gear reduction unit.

d. spider gears.

////////////////////////////////

a.

36.

When the vehicle operator desires more pulling power with less speed; or very little power with high speed, it is necessary to select the proper transmission gear. This gear selection is accomplished by shifting the transmission gear lever to a desired setting. Which of the statements below define the purpose of a selective gear mechanical transmission?

a. The transmission provides for a variety of gear ratios at the differential.

b. The transmission provides a means for connecting and disconnecting the engine from or to the differential.

c. The transmission provides a means of connecting or disconnecting the propeller shaft to or from the differential.

d. The transmission provides for a variety of speed and power selections.

////////////////////////////////

d.

37.

Selective gear mechanical transmissions have to be shifted by the vehicle operator. In vehicles equipped with automatic transmissions this shifting is done automatically and requires that the operator do nothing except place the selector lever in a forward or reverse position. In any case, all transmissions are designed to provide a

a. variety of speed and power ratios.

b. variety of differential ratios.

c. connecting and disconnecting point between the transmission and differential.

d. connecting and disconnecting point between the differential and the driving axles.

////////////////////////////////

a.

38.

The driving axles of a vehicle rely on the differential for their source of power. The differential, then, is designed to

a. deliver power to the driving axles.

b. deliver power to the transmission.

c. deliver power to the propeller shaft.

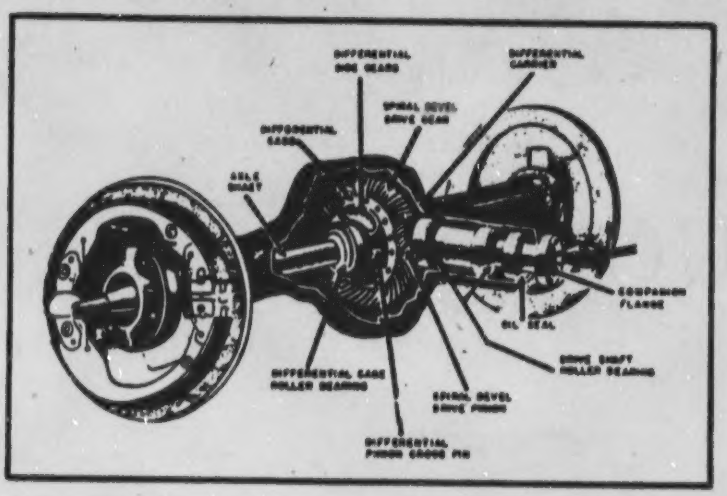
d. deliver power to the dead axles.

////////////////////////////////

a.

39.

Study the diagram below of a differential carefully, then answer the question stated below that diagram.


DIFFERENTIAL SIDE GEARS
DIFFERENTIAL CARRIER
SPIRAL BEVEL DRIVE GEAR
DIFFERENTIAL CASE
AXLE SHAFT
COMPANION FLANGE
OIL SEAL
DRIVE SHAFT ROLLER BEARING
DIFFERENTIAL CASE ROLLER BEARING
SPIRAL BEVEL DRIVE PINION
DIFFERENTIAL PINION CROSS PIN

The differential in a vehicle's power train is designed to

a. connect and disconnect the propeller shaft.

b. connect or disconnect the transmission.

c. transmit power through 90° to the driving axles.

d. transmit power through 90° to the propeller shaft.

//////////////////////////////////

c.

40.

The hood, grille, and inside fender panels of a vehicle body are designed to house the

a. passenger compartment.

b. cargo compartment.

c. power train.

d. engine.

//////////////////////////////////

d.

41.

Most vehicles are equipped with a place to store items which are not normally carried in the passenger compartment. This area is enclosed by the rear deck lid, inner walls of the rear fenders, and contains a spare tire and mountings. This area is called the

a. passenger compartment.

b. engine compartment.

c. cargo compartment.

d. operator compartment.

//////////////////////////////////

The wheels of a vehicle have a tendency to pick up rocks and other materials from the roadway. To prevent these materials from being thrown into the operator's line of vision and to keep them from being thrown at passing motorists, the vehicle is equipped with

a. windows.

b. hood.

c. grills.

d. fenders.

/////////////////////////////////

d.

43.

The part of a vehicle which has a hood, grille, doors, windows, instrument panel, vehicle controls, rear deck lid, spare tire and mountings, and fenders is the

a. passenger compartment.

b. vehicle body.

c. cargo compartment.

d. engine compartment.

/////////////////////////////////

b.

44.

Anything installed on a vehicle for mere comfort rather than being essential to the operation of the vehicle is called an "accessory." Select the statement below which defines accessories.

a. Accessories are items such as headlights, tail lights, horns, and windshield wipers.

b. Accessories are such items as tires, batteries, and fenders.

c. Accessories are such items as ashtrays, cigarette lighters, radios, and heaters.

d. Accessories are such items as instruments, gear shift levers, and turn signals.

/////////////////////////////////

c.

45.

Throughout the entire automotive industry certain terms and phrases have been accepted. For example: If you say that a piston in an engine has .004 of an inch clearance in the cylinder, then this measurement becomes what is known as a "specification." Which of the statements below are specifications?

a. Statements describing general facts or conditions.

b. Manuals describing general repair instructions.

c. Manuals describing general overhaul instructions.

d. Precise measurements used as guides to make adjustments.

////////////////////////////////

d.

46.

When you read a repair manual or shop manual that tells you that the breaker points in a distributor are set at .030 of in inch, and that spark plugs are gapped to .028 of an inch, these measurements are referred to as

a. specifications.

b. measurements in general.

c. settings in general.

d. calibrations in general.

////////////////////////////////

a.

47.

Specifications are defined as

a. measurements in general.

b. precise and exact measurements used as guides.

c. repair or shop manuals that tell the gap setting for spark plugs.

d. statements describing general conditions and facts about the vehicle.

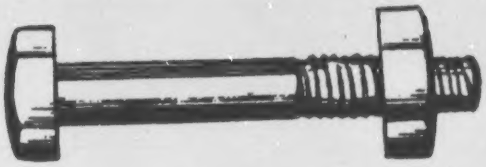
////////////////////////////////

b.

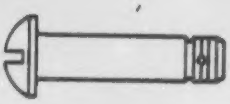
Since beginning this program, you have been devoting most of your time and efforts to learning some of the terminology associated with automobiles in general. For the next series of frames, you will learn a few of the items which help hold this automobile together. As you probably know, automotive parts are assembled with some sort of fastener. There are many different types and designs of fasteners, so begin by studying some of them.

Go to frame 49.

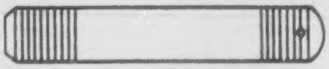
A stud is a type of fastener defined as a "headless shank with threads on each end." In the figures shown below, identify the stud.



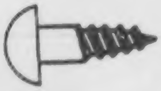
a.



b.



c.



d.

////////////////////////////////

c.

50.

A headless shank with threads on each end is a

a. hex bolt.

b. cap screw.

c. machine screw.

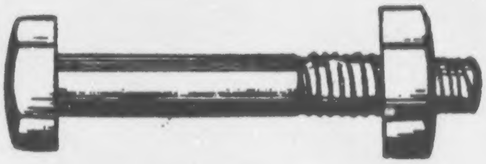
d. stud.

////////////////////////////////

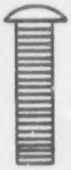
d.

51.

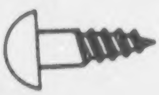
Bolts are rods having a head on one end and threads on the other end; nuts are perforated blocks with internal threads. Nuts are designed to be screwed onto bolts. Identify the nut and bolt assembly in the figures below.



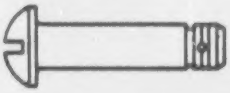
a.



b.



c.



d.

////////////////////////////////

a.

52.

A rod having a head on one end and threads on the other end is a

- a. stud.
- b. screw.
- c. bolt.
- d. rivet.

//////////////////////////////////

c.

53.

A perforated block with internal threads is a

- a. nut.
- b. lockwasher.
- c. snap ring.
- d. cotter pins.

//////////////////////////////////

a.

54.

A screw is a cylindrical rod having a continuous helical rib. It is similar to a bolt except that the threaded end is tapered to fit a tapped hole. The screw does not require a nut. Screws are used to fasten such items as

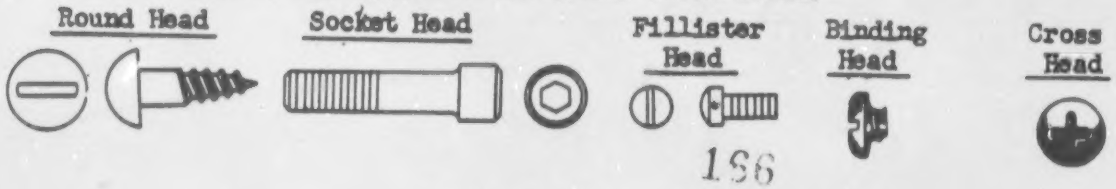
- a. engine heads to blocks.
- b. sheet metal together.
- c. shoes to brake drums.
- d. transmission housings.

//////////////////////////////////

b.

55.

The diagrams below show some of the types of screws you as a mechanic may be required to use. Study the diagrams carefully so you can readily recognize different types of screws and screw heads.



//////////////////////////////////

Go to next frame.
No response required here.

Washers are manufactured in various sizes and shapes. Two of the most common types of washers are plain washers and lock washers. Plain washers are a solid ring of metal which forms a seat for the head of a bolt or nut. Lock washers are either a solid or broken ring which, when compressed, prevents a bolt or nut from loosening. Lock washers are designed to

a. prevent a bolt or nut from loosening.

b. prevent a cotterpin from slipping.

c. be used the same way as a snap ring.

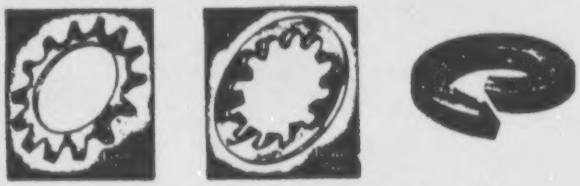
d. do the same job as a stud.

////////////////////////////////

a.

57.

These three types of lockwashers are the most common types in use in the automotive industry. Look at the pictures and familiarize yourself with these different types of lockwashers.



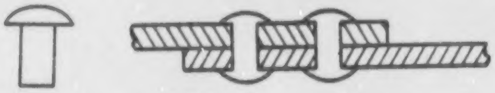
Types of Lockwashers

/////////////////////////////////

Go on to the next frame.
No response required here.

58.

The diagram below shows a rivet before use and after it has been used. Study the diagram carefully and then answer the question stated below.



Which of theses statements is true?

a. Rivets are a headed shank with threads that must be pressed or beat into a permanent adherency.

b. Rivets are a headed shank with no threads that are beat or pressed to form another permanent head.

c. Rivets are headless shanks which are beaten or pressed into place and are temporary in nature.

d. Rivets are not strong enough to hold two or more pieces of material together.

////////////////////////////////

b.

59.

Some shafts are manufactured with a groove cut around them. After all necessary gears and collars have been installed on the shaft, a snapring is inserted in the groove to keep the collar or gear in place. So, we can say that the purpose of a snapring is to prevent

a. endwise movement of a gear or collar on a shaft.

b. a shaft from turning after the gears have been installed.

c. the gear or collar from turning after it has been installed.

d. endwise movement of a shaft after installation of gears or collars.

/////////////////////////////////

a.

60.

Figure A below shows the two types of snap rings (external and internal). Figure B shows an internal snap ring (component #1) which fits into an internal groove machined in one of the other components. An external snapring would fit into a groove on the exterior surface of a component.

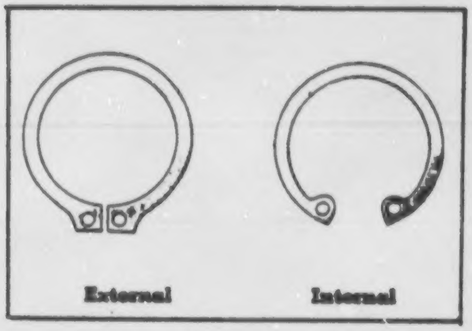


Figure A

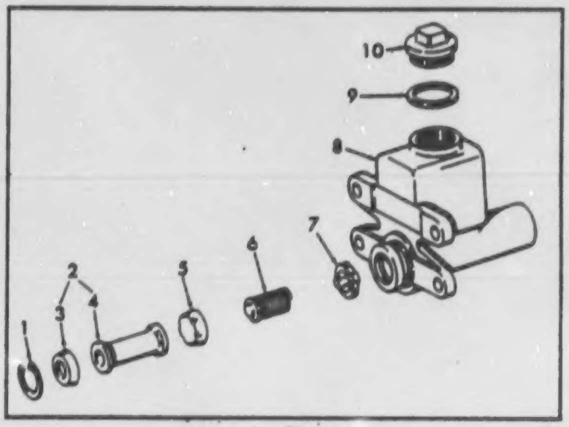


Figure B

The purpose of external or internal snaprings is to

a. prevent a shaft or other component from having endwise movement.

b. prevent a shaft or collar from turning.

c. prevent a gear from turning on a shaft.

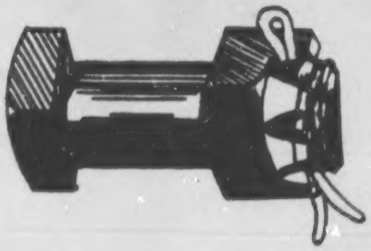
d. prevent a shaft or collar from moving in any direction.

/////////////////////////////////

a.

61.

Cotter pins are types of fasteners also. A cotter pin is a "split" metal pin which is inserted in a hole and then spread apart, one half each way. What is the purpose of the cotter pin in the figure shown below.



a. To hold the bolt in place.

b. To keep the nut from loosening.

c. To keep the nut from damaging the bolt threads.

d. To keep the nut from wobbling and thereby ruining the nut threads.

////////////////////////////////

b.

62.

Metal pins which are inserted in a hole and spread two ways to keep nuts from loosening are called

a. snaprings.

b. rivets.

c. studs.

d. cotter pins.

////////////////////////////////

d.

63.

Threads are measured by their diameter, with the number of threads per inch determining the thread pitch. The relationship of a bolt or stud thread to its counterparts, the nut or tapped hole, refers to its fit. The three things that should be known about threads are

a. circumference, angle, and fit.

b. diameter, circumference, and angle.

c. diameter, fit, and pitch.

d. angle, pitch, and fit.

////////////////////////////////

c.

64.

When determining the diameter of a bolt or screw thread, you should remember that you are concerned with the largest part of the threaded area. This means that thread measurements should be made at the

a. headless end.

b. first turn of the thread nearest the headless end.

c. last thread nearest the headed end.

d. middle of the bolt or screw.

////////////////////////////////

c.

65.

The number of threads per inch of a bolt is determined by use of a screw pitch gauge. Number of threads per inch refers to the

a. length.

b. diameter.

c. coarseness.

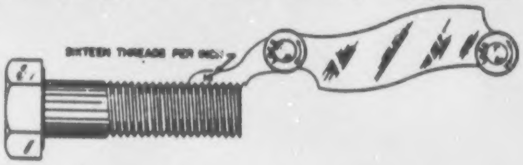
d. pitch.

////////////////////////////////

d.

66.

Look at the diagram of the screw pitch gauge as shown below. When the blade of the screw pitch gauge fits the threads of a screw you have determined the

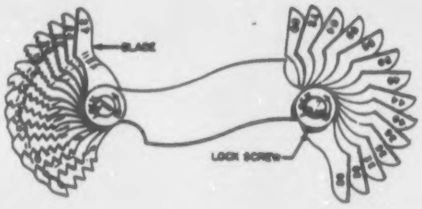


a. width of threads.

b. coarseness of threads.

c. threads per inch.

d. length of screw.



////////////////////////////////

c.

152

The instrument used to check the number of threads per inch is

a. a screw pitch micrometer.

b. a screw pitch gauge.

c. an outside caliper.

d. an inside caliper.

////////////////////////////////

b.

68.

"Fit," pertaining to a bolt and nut, simply means that the

a. nut and bolt have different types of threads.

b. nut and bolt have the same size and kind of threads.

c. nut has larger threads than the bolt.

d. bolt has larger threads than the nut.

////////////////////////////////

b.

69.

The relationship of the bolt threads to the nut or tapped hole threads is the

a. pitch.

b. fit.

c. diameter.

d. size.

////////////////////////////////

b.

70.

Keys are used to lock gears, pulleys, and collars to shafts. Figure A shows a "Woodruff" key. The half-moon shape of the Woodruff key fits into a key seat on a shaft leaving a small portion of the top flat surface exposed. The gear or pulley has a groove which fits this exposed portion to keep the keyed components turning together. Study figure B then answer the question below.

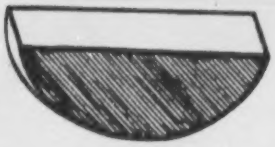


Figure A.

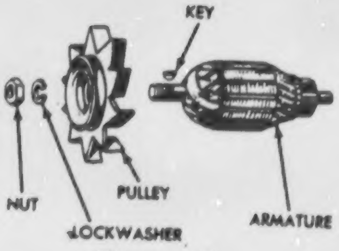


Figure B.

In figure B, when the unit is assembled, which component will be keyed on the armature shaft?

a. Nut.

b. Lock washer.

c. Pulley.

d. None of the components.

//////////////////////////////////

c.

71.

Keys are designed to

a. force a pulley, collar, or gear to turn with the shaft.

b. force a pulley, collar, or gear to turn independently of the shaft.

c. force a shaft to turn independently of the gear, collar, or pulley.

d. hold a shaft in a stationary position.

//////////////////////////////////

a.

END OF PROGRAM. Consult your instructor for further instructions.

PREPARE THE MAN

232
PROGRAMMED TEXT 3ABR47330-PT-102B
3ABR42133-PT-205B
3ABR47231-1-PT-102A
3ABR47231A-PT-102A
3ABR47231B-PT-102A
3ABR47231C-PT-102A
3ABR47230-PT-106

Technical Training

8-9

General Purpose Vehicle Repairman
Aerospace Ground Equipment Repairman
Special Vehicle Repairman
(Towing and Servicing Vehicles)
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)
Base Maintenance Equipment Repairman

MECHANIC'S HANDTOOLS

17 January 1974

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-102B, 3ABR42133-PT-205B, 3ABR47231-1-PT-102A, 3ABR47231A-PT-102A, 3ABR47231B-PT-102A, 3ABR47231C-PT-102A, 6 June 1972.
OPR: TWS
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Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was designed for use in 3ABR47330, Automotive Repairman course. The text was validated in 1964, using 30 students from the subject course. At least 90% of the students used in the validation exercise achieved the objectives as stated. The text has been used in several other ABR courses, and has trained approximately 5,000 students. It is considered to be still valid. Satisfactory performance is demonstrated by achievement of 85% on a written test.

OBJECTIVES

After completion of this programmed text, you will be able to:

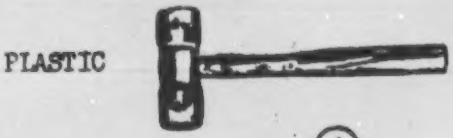
1. Select the correct name of each type of hammer shown.
2. State the correct use of each type of hammer shown.
3. Identify each type of screwdriver shown.
4. From a list, select the correct use for each type of pliers.
5. Match a list of names of wrenches to the wrenches.
6. Identify the names of files.
7. Select the correct use for each type of chisel shown.
8. Select the proper hacksaw blade for any given task.

INSTRUCTIONS

This program presents information in small steps called "frames." After each step you are asked to select the statement, match items, or otherwise make some sort of discrimination. Use a piece of paper or a card as a mask to cover the printed material. Slide this mask down the page until you expose the top of a short row of slashes (//////////). One small step or "frame" is now exposed. Read the material presented and make your response as directed by the instructions. Slide the mask down and compare your answer with the correct one. If your answer is correct go on to the next frame; if you are wrong, read the frame again.

Frame 1

Hammers are tools consisting of a head and a handle. Each Hammer has its own special use. The good mechanic learns to select the correct hammer for the particular work at hand.



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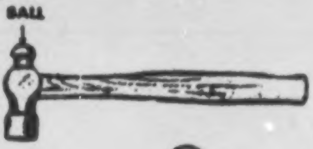

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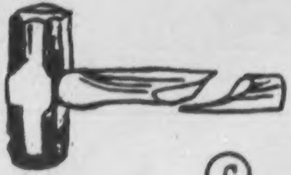


Ⓒ

Match the hammer shown above the nomenclatures below:

_____Sledge, hand, double face, 5 lbs.

_____Hammer, hand, machinist, ball peen, 1 lb.

_____Hammer, hand, face diameter 1 1/2 inch, screw-in inserted face, plastic, 1 1/4 lb.

/////////////////////

C
B
A

Frame 2

Hammers are generally classified as "hard face" hammers and "soft face" hammers. Hard face hammers are made of steel. Soft face hammers have a face made of material softer than steel, for example: lead, plastic, and rubber.

Hammers are further classified according to the weight of the head (without the handle) and they range from 4 ounces to 20 pounds in size.

Answer each of the following statements as either true (T) or false (F).

_____Hammer size is determined by the weight of the hammer head.

_____Soft faced hammers are made of steel.

_____Hard faced hammers are made of such materials as lead, plastic, or rubber.

/////////////////////

T
F
F

Frame 3

The following statements describe the uses of different types of hammers. Read each statement and then answer the matching problem.

1. One of the best general purpose hammers is the ball peen hammer. The rounded end is known as the "peening end" and is used by auto mechanics to form gaskets.

2. The soft faced hammers are used where steel hammers might mar or injure the work.

3. Sledge hammers are used only where heavy blows are necessary.

Match each of the hammers in column B with the proper use in column A.

Column A

_____Used where heavy blows are required.

_____Used where steel hammers may mar the work.

_____Used for forming gaskets and other light work.

Column B

A. Ball peen hammer.

B. Plastic face hammer.

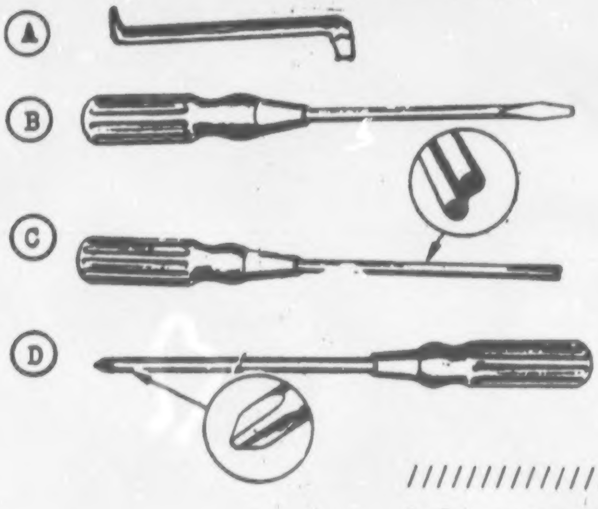
C. Sledge hammer.

////////////////////

C
B
A

Frame 4

Screwdrivers are classified by the types of points they have. The screwdrivers points are: common, crosspoint, and clutchhead. Study the illustrations below of the four screwdrivers and then answer the matching question at the top of the next page using the letter coded illustrations below.



The offset screwdriver has a sharp bend at each end. It has flat tips.

Everyone is familiar with the common screwdriver - it has a flat tip.

The clutchhead screwdriver stands alone in that it doesn't resemble any other type.

The crosspoint screwdriver family includes both the Phillips, and the Reed & Prince types.

////////////////////

Information panel only.

Frame 5

Match the items shown in frame 4 with the nomenchature below:

_____Screwdriver, flat tip, 3/8-inch wide tip, 6-inch long blade.

_____Screwdriver, crosspoint, 6-inch long blade.

_____Screwdriver, flat tip, offset, 4 1/2 inch long.

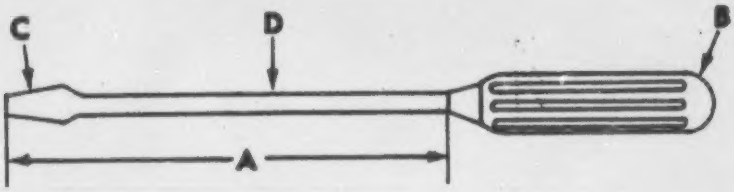
_____Screwdriver, clutchhead, 6-inch long blade.

//////////////////////

B
D
A
C

Frame 6

A screwdriver is similar to a knife in construction in that it consists of a blade and a handle. Study the drawing below of the screwdriver and answer the matching question below.



Match the items lettered in the drawing above with the statements listed below:

_____Tip.

_____Handle.

_____Blade.

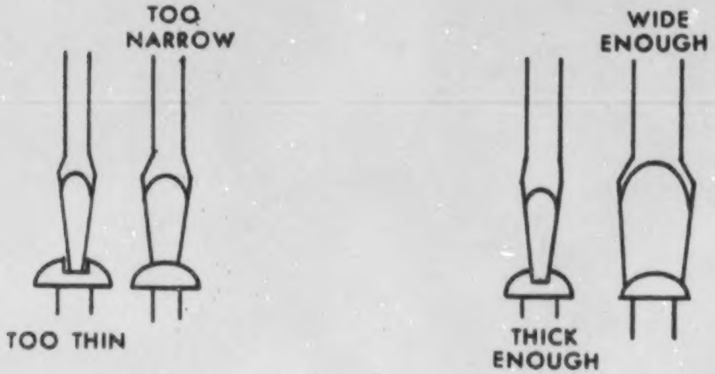
_____Dimension used to determine the specified length of a screwdriver.

//////////////////////

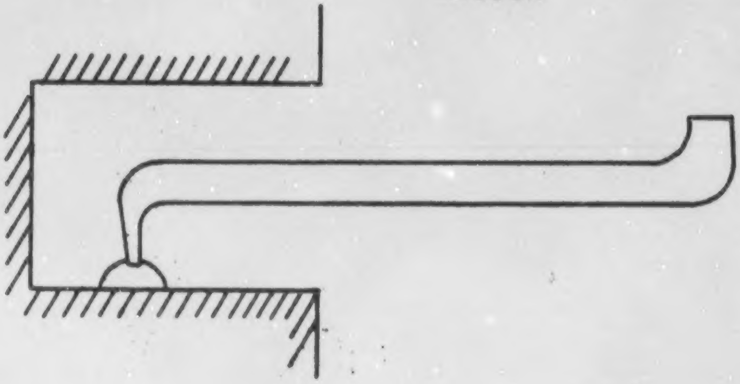
C
B
D
A

Frame 7

Study the drawings below and then answer each of the following statements as being either true (T) or false (F).



Correct amount of pressure must be applied.



_____Damage to screwheads and screwdrivers is reduced when the proper sized screwdriver is used.

_____It is important that the correct amount of pressure be applied to the screwdriver when installing or removing screws.

_____An offset screwdriver can be used to remove screws that cannot be reached by other screwdrivers.

_____An offset screwdriver has a tip like any common screwdriver, except that it has a sharp bend at each end; this is why it is called "offset" (not in line).

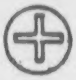
////////////////////

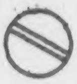
T
T
T
T

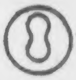
Frame 8

Match each screwdriver named in Column B with the proper item in Column A.

Column A

_____ 

_____ 

_____ 

_____ Used in tight quarters where other screwdrivers cannot get at the screw head to be turned.

Column B

A. Offset screwdriver.

B. Crosspoint screwdriver.

C. Common screwdriver.

D. Clutchhead screwdriver.

////////////////////

B
C
D
A

Frame 9

Select the correct answer:

The length of a common screwdriver is determined by the

a. length of the blade.

b. overall length of the screwdriver.

c. length of the handle.

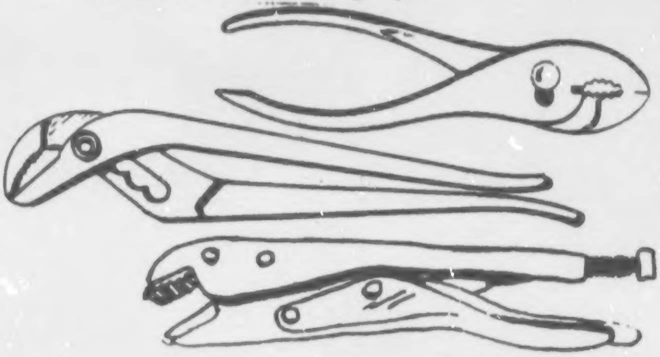
////////////////////

a.

Frame 10

Pliers are available in various types and sizes in the mechanic's tool box. They are primarily an extension to the hand and are used to hold a material which the hand is not strong enough to grasp tightly. Pliers are not intended to be used as replacements for wrenches.

The adjustable pliers include: slip-joint pliers, water pump pliers, and vise grips.



A. Slip-joint pliers are the most common type of pliers - known and used by all.

B. Water pump pliers are the largest of this group, both in size and in jaw capacity.

C. Vise grips are technically referred to as a form of wrench.

Match the items above with the nomenclature below:

_____Pliers, combination slip joint, 7-inch.

_____Wrench, plier, straight jaw, 8-inch.

_____Pliers, waterpump packing, 10-inch.

////////////////////

A C B

Frame 11

Water pump pliers were originally designed to tighten water pump packing gland nuts on cars in the 1920's. They are no longer needed for that purpose, however, they are very effective as a "large capacity" holding tool.

Vise grip pliers have a locking device on one jaw. Once adjusted and "locked on" it's like putting an object in a small vise. (Hence, the name of vise grip.) This leaves your hands free for other work.

The most commonly used pliers are the slip-joint pliers. They also serve as a holding implement.

Match the most suitable type pliers to use for each of the following:

A. Slip-joint pliers.

B. Water pump pliers.

C. Vise grip pliers.

_____For general purpse use such as bending, holding, or twisting wire or metal.

_____To lock two pieces of sheet metal together in preparation for drilling.

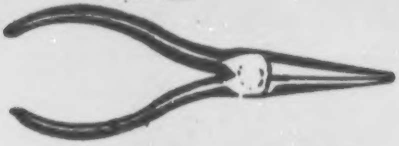
_____For holding large objects like pipes.

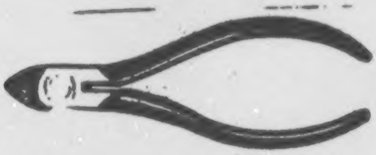
////////////////////

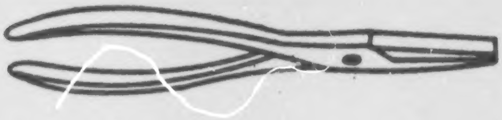
A C B

Frame 12

Non-adjustable jaw pliers include: diagonal cutting pliers, long nose pliers, and round jaw pliers. These pliers are all about the same size.







A. As the name implies, the long nose pliers (sometimes called needle nose), has the longest jaws of the group.

B. The diagonal cutting pliers have the shortest jaws (also the sharpest) of the group.

C. The round jaw pliers have neither longest nor the shortest jaws of this group. However, they do have the "roundest" jaws - that's right, just like two of your fingers side-by-side. NO FLATS at all.

Match the items above with the nomenclature below:

_____Pliers, diagonal cutting, short nose type, 6-inch.

_____Pliers, straight needle nose, 6 1/2-inch.

_____Pliers, round nose, round jaws, 6-inch.

////////////////////

B A C

Frame 13

There is a certain amount of overlap in the uses of some types of pliers, however, these are designed for specific uses.

1. Pliers with sharp cutting jaws are designed for cutting wire, cotter pins, etc.

2. Pliers with long slender jaws are designed to reach into tight places where the fingers cannot be used.

3. Pliers with round jaws are designed for forming round designs, in wire, metal, etc.

Match the type pliers most suitable to use with each of the following:

A. Diagonal cutting pliers.

B. Round jaw pliers.

C. Long nose pliers.

_____To form a small loop on the end of an electrical wire to place on a terminal.

_____To reach into a confined place to make an adjustment.

_____To cut a piece of wire.

////////////////////

B C A

Frame 14

The different uses for pliers are listed in Column A, the types of pliers are listed in Column B. Match the pliers in Column B with the correct use in Column A.

Column A	Column B
_____Used for forming small loops in wire.	A. Slip-joint pliers.
_____Used for holding objects in confined places or making delicate adjustments.	B. Diagonal cutting pliers.
_____Used for cutting wire and removing cotter pins.	C. Long nose pliers.
_____Used for bending, holding, or twisting metal or wire (general purpose uses).	D. Water pump pliers.
_____Originally designed for tightening water pump packings on early automobiles. Used as a general purpose holding tool.	E. Round jaw pliers.
_____Used as a locking device while working on an object with other tools.	F. Vise grips.

////////////////////

E
C
B
A
D
F

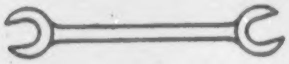
Continue to next page immediately.

Frame 15

Wrenches are tools used for tightening or loosening nuts and bolts.

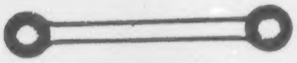
Included in the classification of wrenches are: open end wrenches, box end wrenches, adjustable jaw wrenches, and the socket screw wrenches.

A.



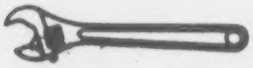
Open end wrenches are solid, nonadjustable wrenches with open, parallel jaws.

B.



Box end wrenches are solid, non-adjustable wrenches with the ends enclosed or boxed in.

C.



Adjustable jaw wrenches are similar in shape to one end of a regular open end wrench except that it has one moveable jaw.

D.

Socket screw wrenches are L-shaped six sided rods, sometimes referred to as "keys."

Match the wrenches above with the nomenclature below:

_____Key, socket head, hexagon, L type handle, 1/4-inch.

_____Wrench, box, angular offset, double head type, 12 point, 7/16 x 1/2-inch.

_____Wrench, open end, fixed double head, 15 degree angle, 9/16 x 5/8-inch.

_____Wrench, open end, adjustable jaw, single head, 6 inches long.

////////////////////

D
B
A
C

Frame 16

The correct type and size of wrench should always be used when tightening or loosening nuts and bolts.

The box end wrenches are well suited for use in close quarters because their heads are small.

The open end wrenches are used when a box end wrench cannot be used.

The adjustable jaw wrenches are useful for odd size nuts. Because they are weaker than other wrenches they should only be used where the required torque is not too great.

Internal wrenching bolts and nuts require the use of a socket screw wrench.

Match the proper wrench to the following uses:

_____To loosen an internal wrenching set screw. A. Adjustable jaw.

_____To tighten a nut on an oil line fitting. B. Box end.

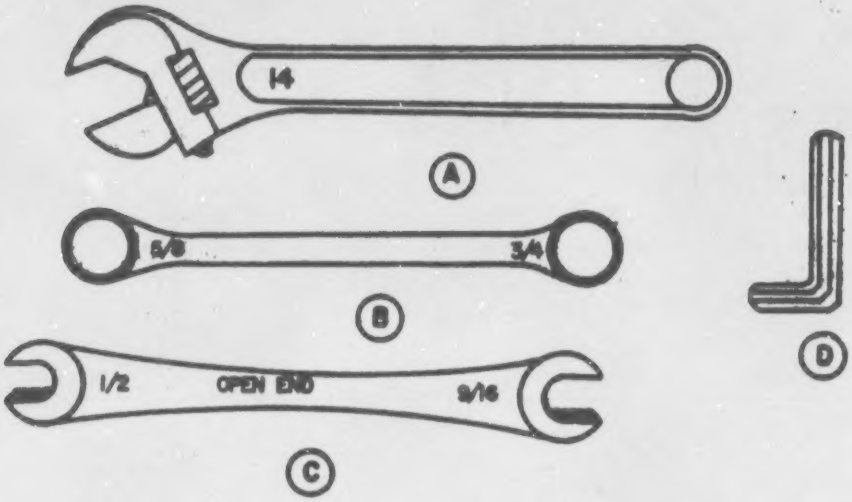
_____To turn a nut in a hard-to-reach place. C. Open end.

_____Where other available wrenches do not fit the nut to be removed. D. Socket screw.

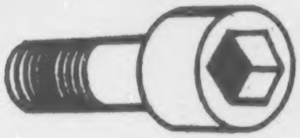
////////////////////

D
C
B
A

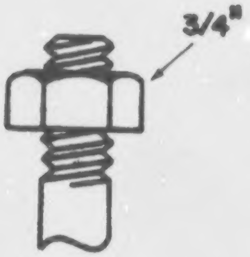
Frame 17


14
Ⓐ
5/8
3/4
Ⓑ
1/2
OPEN END
9/16
Ⓒ
Ⓓ

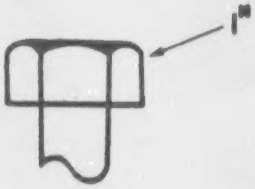
Study the sizes of the wrenches shown above: THEN select the proper wrench to be used for each nut or bolt shown below.



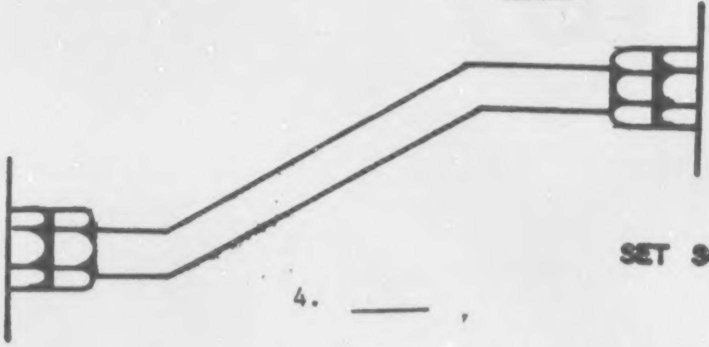
1. ____



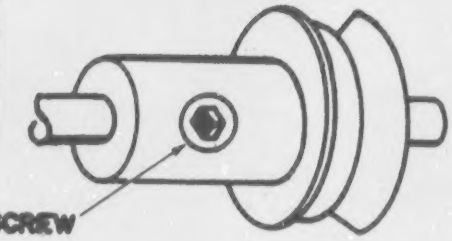
2. ____



3. ____



4. ____



5. ____

//////////////////////

1. D
2. B
3. A
4. C
5. D

Frame 18

The use of wrenches are listed in Column A, the types are listed in Column B. Match each wrench in Column B with its proper use in Column A.

Column A	Column B
_____Used on internal wrenching hexagon bolts, plugs, and set screws.	A. Open end wrench.
_____Must be used on gas and oil line fittings.	B. Adjustable jaw wrench.
_____Used in hard to reach places. It completely surrounds the bolt head or nut to be turned.	C. Socket screw wrench.
_____Will fit any bolt or nut within its range and works satisfactorily for adjustments, or where the turning effort (torque) is not too great.	D. Box end wrench.

////////////////////

C A D B

Frame 19

Match the pliers in Column B with its proper use in Column A.

Column A	Column B
_____Originally designed for tightening water pump packings on cars and used as a general purpose holding tool.	A. Diagonal cutting.
_____General purpose uses (bending, twisting, or holding metal or wire.	B. Slip joint.
_____Cutting wire and removing cotter pins.	C. Long nose.
_____A locking device while working on an object with other tools.	D. Water pump.
_____Forming small loops in wire.	E. Vise grip.
_____Holding objects in confined places or making delicate adjustments.	F. Round jaw.

////////////////////

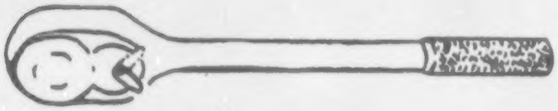
D, B, A, E, F, C

Frame 20

Socket wrenches are made up of different combinations of parts. The socket is the part that fits on the nut or bolt head.

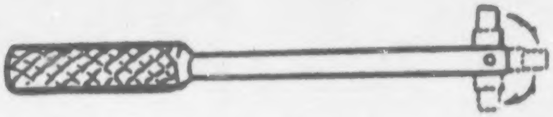
Sockets are detachable from the socket handles by snapping them ON or OFF the handle drives.

Ⓐ



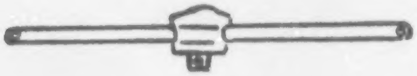
The ratchet handle has a small lever on the ratchet handle head used to select the direction of drive.

Ⓑ



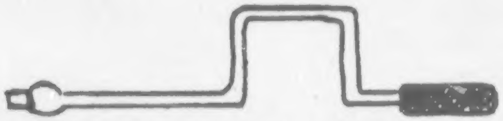
The hinge handle has a hinge between the handle and the socket drive.

Ⓒ



The T-handle resembles the letter "T." (A bit on the short and broad side.)

Ⓓ



(not shown in scale)

The speed handle resembles a crank.

Match the handles illustrated above with the nomenclature below:

_____Handle, socket wrench, ratchet, 3/8-inch drive.

_____Handle, socket wrench, sliding T, 3/8-inch drive.

_____Handle, socket wrench, hinged, 3/8-inch drive, 8-inch o/a length.

_____Handle, socket wrench, speeder, 3/8-inch drive.

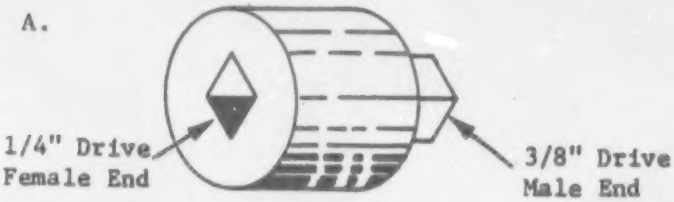
////////////////////

A
C
B
D

Frame 21

In addition to the socket handles there are: sockets, extensions, and adapters made in many different sizes to fit specific types of work.

A.

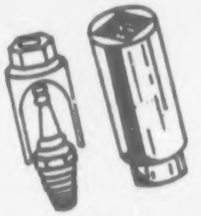


Adapters provide the means for changing drive size - 1/4" to 3/8" to 1/2", etc.

B.

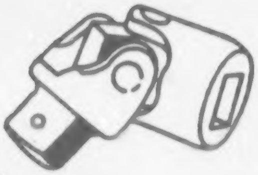
An extension is a bar that extends the drive length. They come in many lengths.

C.



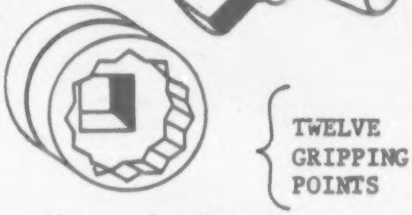
The sparkplug holding socket has six points that fit the sparkplug closely so that the socket cannot "cock" and break the porcelain on the spark plug.

D.



Universal joints permit work where a straight wrench cannot be used.

E.



The socket is what fits on the nut or bolt. They come in many sizes.

Match the items above with the nomenclature below.

_____Universal joint, socket wrench, 3/8-inch drive.

_____Socket, socket wrench, 12 point, sparkplug holding, 1/2-inch drive.

_____Socket, socket wrench, 12 point, 5/8-inch size, 3/8-inch drive.

_____Adapter, socket wrench, male 3/8-inch square drive, female 1/4-inch square drive.

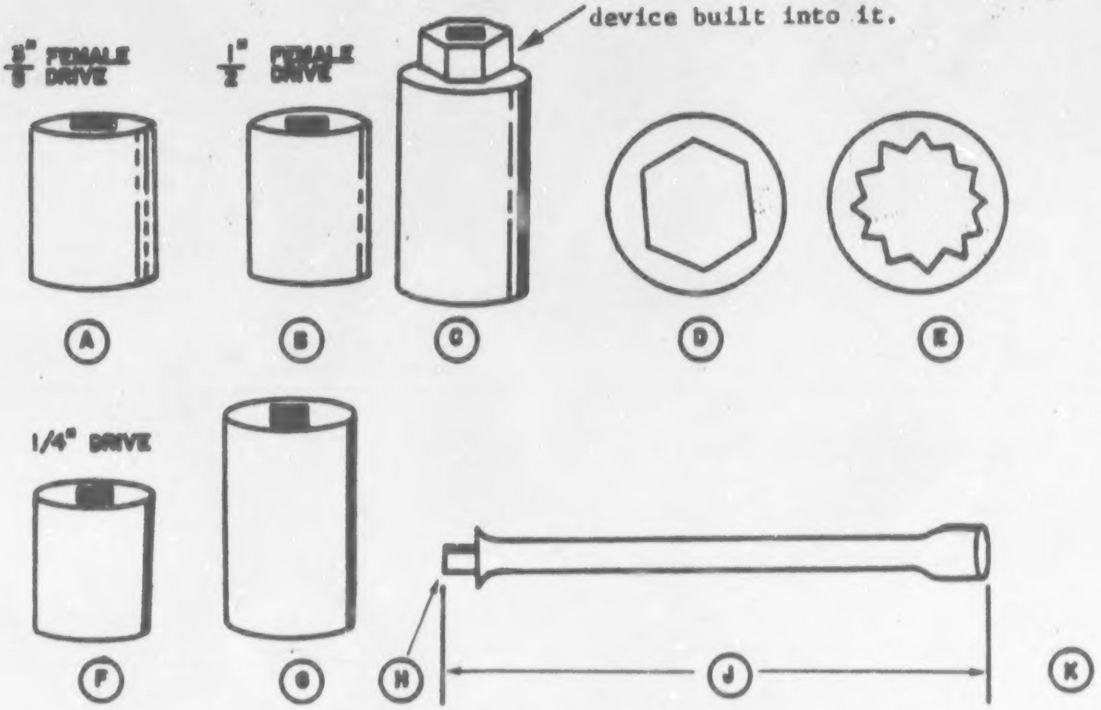
_____Extension, socket wrench, square shape end, 3/8-inch size, 4 inches long.

////////////////////

D
C
E
A
B

Frame 22

Note: This socket has a holding device built into it.


3/8" FEMALE DRIVE
1/2" FEMALE DRIVE
A
B
C
D
E
1/4" DRIVE
F
G
H
J
K

Match the items illustrated above with the statements listed below:

_____Sparkplug holding socket.

_____Six point socket.

_____12 point socket.

_____Male drive end.

_____Female drive end.

_____Extension length.

_____Standard socket.

_____Deep socket.

_____1/2" square drive socket, 3/4" size.

_____3/8" square drive socket, 3/4" size.

_____1/4" square drive socket, 1/2" size.

_____The socket required to turn a 3/4" nut with a 3/8" male drive handle.

////////////////////

C	A, B, or F
D	G
E	B
H	A
K	F
J	A

171

Frame 23

Answer each of the following statements as either true (T) or false (F).

_____The size of socket drives are determined by the dimension of the square end of the drive and the square hole in the socket.

_____Due to the various choices of handles, and the variety of drives and adapters the socket wrench can be used for many different jobs.

_____The sparkplug holding socket has a holding device built into it to grip and hold the sparkplug in the socket so that it will not fall out during removal or installation.

_____The purpose of a wrench is to tighten and loosen nuts and bolts.

_____The types of sockets are: standard, deep, sparkplug holding and impact.

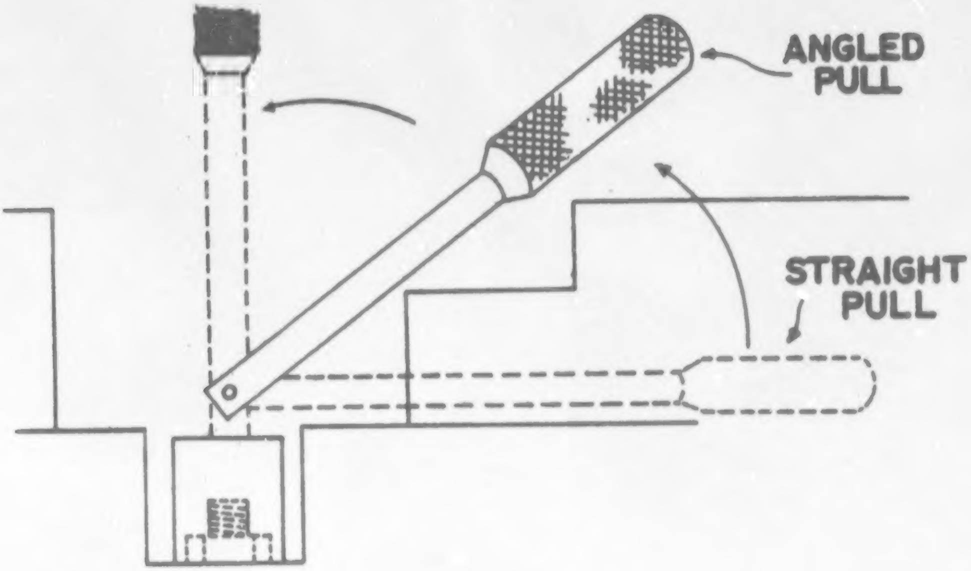
////////////////////

T
T
T
T
T

190

Frame 24

Since sockets are detachable from the handles, a variety of handles may be used for different kinds of work.



The hinge handle is the strongest handle in the tool box and because of this it is used to break loose stubborn bolts and nuts. To loosen a nut the handle can be used at right angles to the socket for a straight pull, as shown in the figure above. If this is not possible an angled pull may be used. After the nut is loosened the handle can be moved on its hinge to the vertical position and twisted by the fingers to remove the nut.

Answer each of the following statements as either true (T) or false (F).

_____The hinge handle can be used for a straight (90 degree) pull if desired.

_____The hinge handle will provide any angle of pull desired.

_____Tight or "stubborn" nuts or bolts should be loosened with a hinge handle.

////////////////////

T
T
T

Frame 25

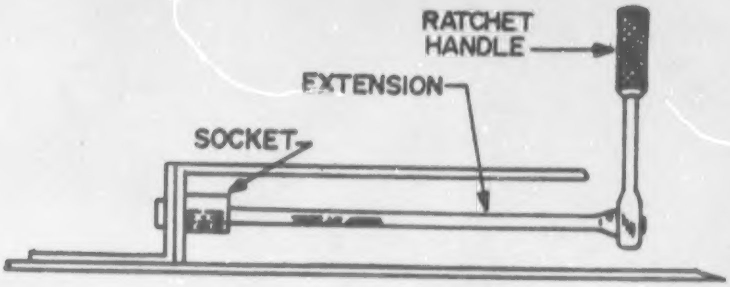


Figure 1. Use of the Ratchet Handle.

A pawl in the ratchet handle head engages into ratchet teeth. Pulling on the handle in one direction causes the pull to hold or to lock the ratchet teeth and turn the socket. Moving the handle in the opposite direction causes the pawl to ratchet (slip) and the handle will back up without turning the socket. Because of this action the handle can be worked rapidly and the socket does not have to be raised off the nut to get another "bite" (see figure 1 above).

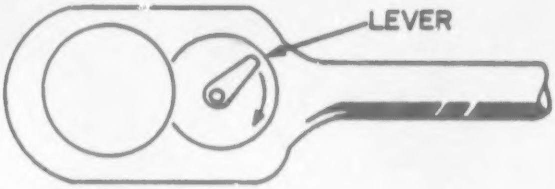


Figure 2. Ratchet Handle Head.

The handle ratchets in one direction when loosening a nut and in the other direction when tightening a nut. There is a lever on the ratchet handle head that is used to change the direction of the ratchet action (see figure 2 above).

Answer the following statements as either true (T) or false (F).

_____The ratchet handle drives in one direction and slips in the other.

_____When you can't get a straight pull on a nut, the ratchet handle will permit an angled pull.

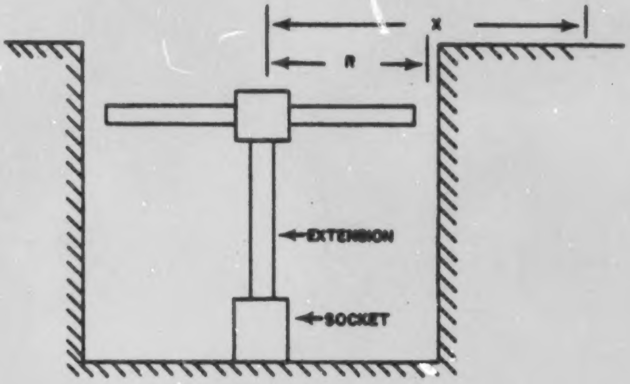
_____The ratchet handle can be operated without having to raise the socket off the nut for another "bite."

////////////////////

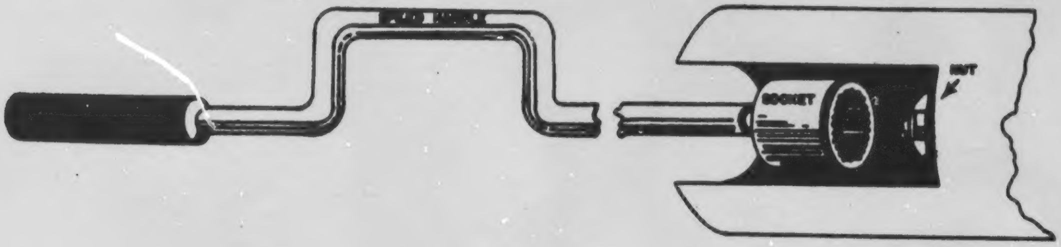
T
F
T

Frame 26

The T-handle is another of the various handles used for driving sockets. The "T" arrangement makes it possible to apply equal force with both hands because the drive is in the center. Another advantage is that the turning radius required is smaller than that needed with other handles, as shown in the illustration to the left. "R" represents the radius for the T-handle. "X" represents the radius needed for another type of handle.



In work areas where there is no space limitation to prevent the speed handle from being turned a full 360 degrees, it affords a rapid means for turning a socket, that is, it takes a lot of room to turn a crank-like tool without skinning your knuckles.



Answer the following statements as either true (T) or false (F).

_____The speed handle is used where the turning radius is limited.

_____The T-handle is used where the swing arc is not limited.

_____The hinge handle is used to break bolts and nuts loose.

_____The ratchet handle drives in one direction and slips in the other.

////////////////////

F F T T

Frame 27

Match the items in Column B to the uses in Column A.

Column A		Column B
_____Used if the socket handle drive isn't long enough or if the working area restricts the movement of tools.	A.	Socket.
_____Used between the socket and the socket handle to reach nuts and bolts at various angles.	B.	Extension.
_____Used to permit the use of a 1/2-inch drive socket with a 3/8-inch drive handle.	C.	Universal joint.
_____Used in the required size to fit directly on the nut or bolt to be returned.	D.	Adapter.

////////////////////

B C D A

Frame 28

Match each handle in Column B with the proper use in Column A.

Column A		Column B
_____When the fast removal or replacement of nuts and bolts is required, and the swing arc is not limited.	A.	T-handle.
_____For breaking nuts and bolts loose and permit the freedom of any angle of pull desired.	B.	Ratchet handle.
_____To tighten or loosen a nut, without having to remove and reposition the socket on the nut, when the swing arc is limited.	C.	Speed handle.
_____When the turning radius is small or when a nut or bolt must be reached through a bulkhead.	D.	Hinge handle.

////////////////////

C D B A

Frame 29

Match the pliers listed in Column B to the proper use listed in Column A.

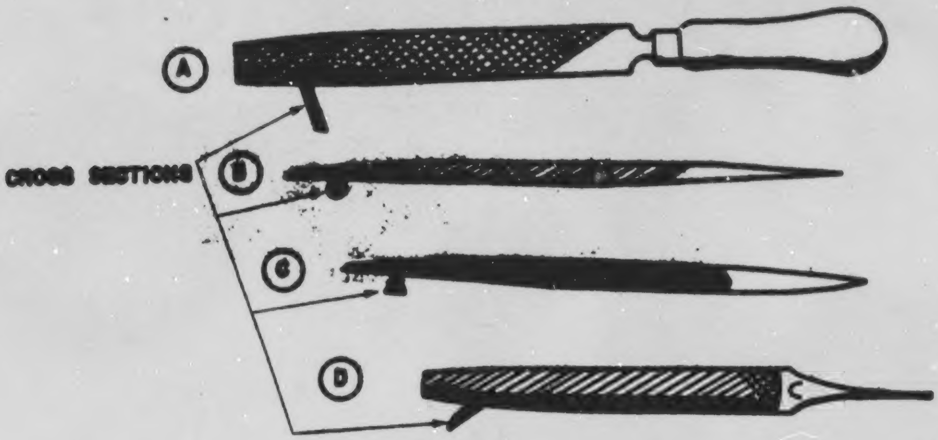
Column A		Column B
_____Used for general purpose holding, bending or twisting of metal or wire.	A.	Round jaw pliers.
	B.	Slip-joint pliers.
_____Used to form small loops in wire.	C.	Water pump pliers.
_____Used for working in confined places and for making delicate adjustments.	D.	Long nose pliers.
_____Used as a general purpose holding tool for large objects.		

//////////////////////

B A D C

Frame 30

Files are tools used for cutting, smoothing, or removing small amounts of metal. They vary in length, shape, and cut of the teeth.



Match the items illustrated above with the nomenclature given below:

_____File, hand, round, bastard, 8-inch (rattail file).

_____File, hand, half round, bastard, 8-inch.

_____File, hand, flat, double cut, coarse, 10-inch.

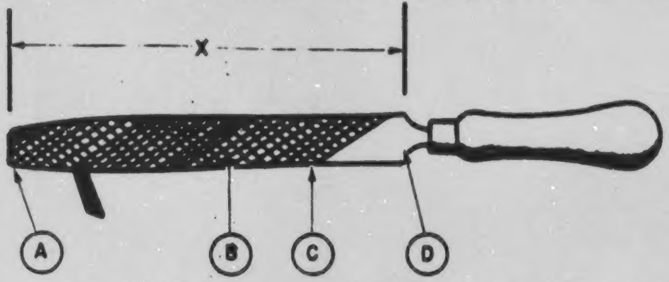
_____File, hand, triangular, single cut, 8-inch.

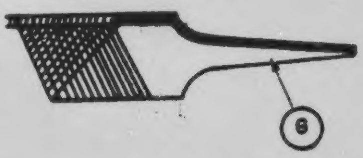
//////////////////////

B D A C

Frame 31

The parts of a file are shown in the illustrations below. Study these drawings and then answer the matching problem stated below. Note the wooden handle on the file shown on the left. Never use a file without a handle as the tang could be driven into your hand.





Match the lettered items in the drawings above with the statements below:

_____File length.

_____File point.

_____File tang (goes into the handle).

_____File edge.

_____File face.

_____File heel.

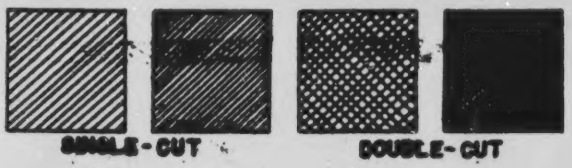
////////////////////

X
A
G

C
B
D

Frame 32

File cuts are shown in the illustration below. Study the drawings and then match the file grade or cut in Column B with the proper file description in Column A.



Column A		Column B
_____A file with the teeth cut deep and far apart.	A.	Coarse grade file.
	B.	Smooth grade file.
_____A file with the teeth cut shallow and close together.	C.	Single cut file.
_____A file with two series of cuts across the face, in two different directions.	D.	Double cut file.
_____A file with only one series of cuts across the face with all cuts parallel to each other.		

////////////////////

A B D C

Frame 33

The following is a list of general rules for the selection of files. Study the four general rules and then answer the matching question below.

1. Use a coarse file for soft material.
2. Use a smooth file for hard material.
3. Use a found file for enlarging round holes.
4. Use a flat file for a flat surface.

Match the correct use of each file in Column B to the file in Column A.

Column A		Column B
_____Triangular file.	A.	For general purpose filing of a large flat surface.
_____Flat file.	B.	For filing or enlarging a large round opening.
_____Rattail file.	C.	For enlarging small round openings.
_____Half round file.	D.	For filing small notches and straightening burred or damaged threads.

////////////////////

D A C B

Frame 34

The procedure for using a file varies with the work to be accomplished and the type of file to be used. However, the general procedure is as follows: Use a smooth, firm forward stroke to "cut" the material being filed. Use only enough pressure to keep the file cutting. DO NOT drag the file during the return stroke or the teeth may be dulled.

Indicate whether each of the following statements are true (T) or false (F).

_____The procedure for using a file is the same for every job.

_____The teeth of a file can be dulled if the file is used improperly.

_____The procedure for using a file is not the same for every job.

_____In order for the file to cut the material, a lot of pressure must be applied.

////////////////////

F T T F

Frame 35

Insufficient pressure on the forward stroke will cause the file teeth to slip over the work, resulting in dulled file teeth. Excessive pressure will overload the file teeth, causing the cut to be irregular.

Match the improper use of a file (Column A) to the condition it will cause (Column B).

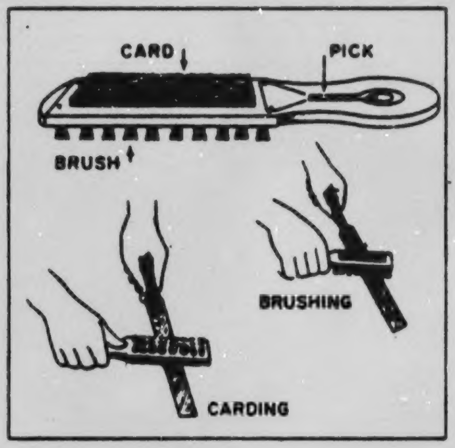
	Column A	Column B
A.	Insufficient pressure.	_____Dulled teeth.
B.	Excessive pressure.	_____Irregular cut.

//////////////////////

A B

Frame 36

When a file is used on soft metal, such as lead, the file should be dragged on the regurn stroke, as this tends to help clean the teeth. Normally a file card is used to clean the file as illustrated below.



//////////////////////

No response was required,
Proceed to the next frame.

Frame 37

Match the items in Column B with the correct use in Column A.

Column A	Column B
_____Used to turn a socket when the turning radius is small.	A. Universal joint.
	B. T-handle.
_____Used when a socket drive is not long enough.	C. Extension.
_____Used between a 3/8-inch socket drive handle and a 1/2-inch drive socket.	D. Adapter.
_____Used in the socket drive to reach nuts and bolts at angles.	

////////////////////

B C D A

Frame 38

Select the correct answer to the following:

Socket drive size refers to the

A. length of the handle.

B. diameter of the sockets.

C. dimension of the square hole in the socket and the square end of the drive.

////////////////////

C

Frame 39

Select the correct answer to the following:

The kinds of sockets are called

A. standard, deep, sparkplug holding, and impact.

B. shallow, standard, and sparkplug holding.

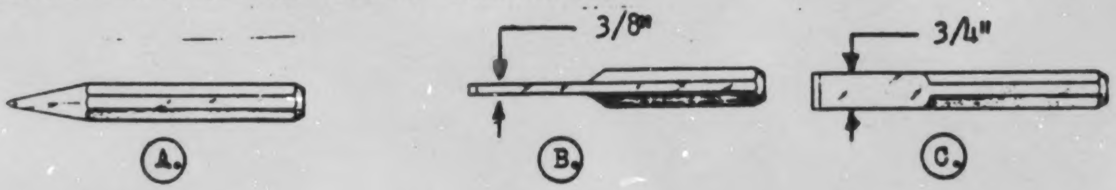
C. box, open end, and adjustable jaw.

////////////////////

A

Frame 40

The cold chisel derives its name from the fact that it can be used to cut "cold" metal (without first softening the metal by heating). Chisels are made in a variety of shapes, suited for different types of work. The figure below illustrates three types of chisels. Match the items below with the correct nomenclature.



_____Chisel, cold, hand, 3/4-inch wide cut, 7 inches long.

_____Chisel, cape, hand, 3/8-inch wide cut.

_____Chisel, diamond point, hand.

////////////////////

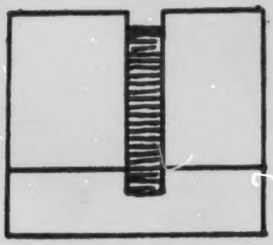
C B A

Frame 41

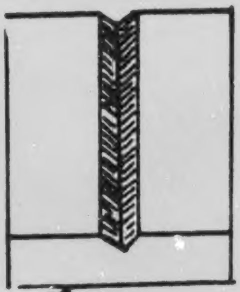
Match each chisel in Column B with the correct use in Column A.

Column A

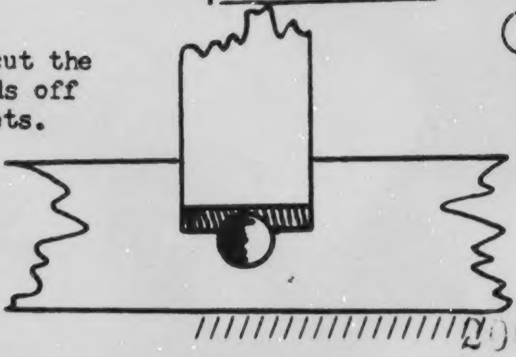
_____ To cut narrow grooves in metal.



_____ To cut "V" grooves in metal.

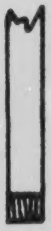


_____ To cut the heads off rivets.

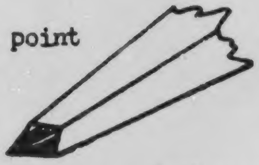


Column B

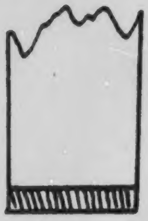
Ⓐ Cape chisel.



Ⓑ Diamond point chisel.



Ⓒ Flat chisel.

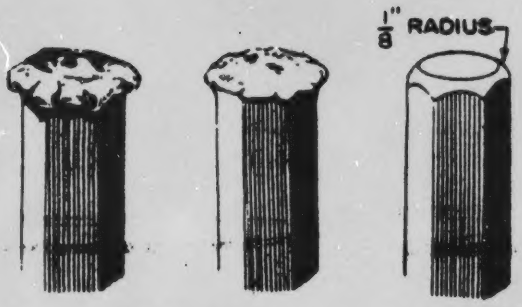


////////////////////200

A B C

182

Frame 42



The chisel at the left is badly mushroomed The one in the center is slightly mushroomed. Both chisels should be dressed until in the condition shown at the right.

Hammering on a chisel causes its head to become mushroomed (see figure to the left). A chisel in this condition should not be used because the bent-over edges are likely to break off and injure someone.

Answer the following statement as being either true (T) or false (F).

_____A chisel with a mushroomed head should be dressed on a grinding wheel to remove all cracks and rolled over edges.

////////////////////

T

Frame 43

Match each chisel in Column B with the correct use in Column A.

Column A		Column B
_____Used to cut off rivet heads, cut sheet metal, and to split nuts.	A.	Flat chisel.
_____Used for cutting narrow grooves in metal.	B.	Cape chisel.
_____Used for cutting "V" grooves and squaring corners in metal.	C.	Diamond point chisel.

////////////////////

A B C

PROCEED TO NEXT FRAME IMMEDIATELY.

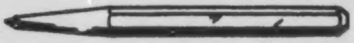
Frame 44

Punches are made of the same material and require the same care as do cold chisels. The work for which they are best suited depends upon their shape. The illustrations below and the descriptions show three types of punches.

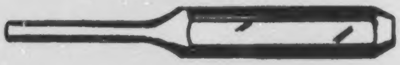
The center punch has a sharp "pointed" end.

The pin punch has a straight point.

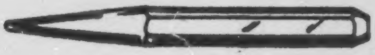
The drift punch has a tapered point.



A.



B.



C.

Match the items illustrated above with the nomenclature listed below:

_____Punch, center, solid, 3/8-inch diameter.

_____Punch, drive pin, straight point 1 1/2-inch ling, 5/32-inch diameter.

_____Punch, drive pin, taper 1 1/2-inch long.

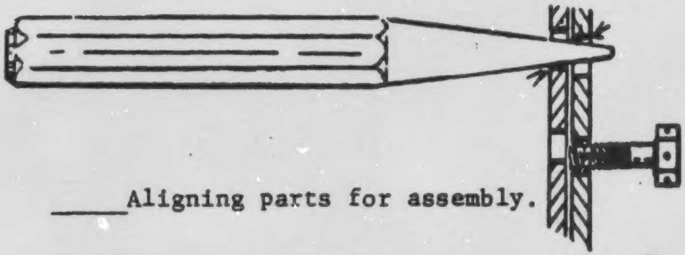
////////////////////

A B C

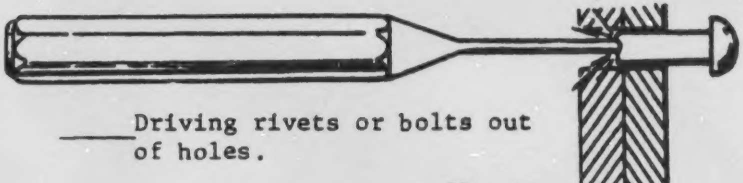
Frame 45

Match each pounch listed in Column B with the correct use shown in Column A.

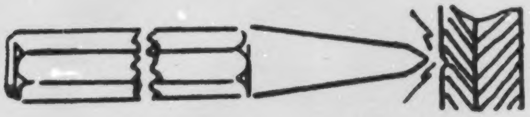
Column A



_____Aligning parts for assembly.



_____Driving rivets or bolts out of holes.



_____To mark the locations of holes to be drilled.

Column B

A. Pin punch

B. Drift punch

C. Center punch

////////////////////

B A C

Frame 46

Match each punch listed in Column B with the correct use listed in Column A.

Column A

_____Used to align the bolt holes of parts for assembly.

_____Used to mark the location of holes to be drilled.

_____Used to drive out bolts or rivets from holes.

Column B

A. Center punch.

B. Drift punch.

C. Pin punch.

////////////////////

B and/or C   A   C

Frame 47

Match each tool in Column B with the proper use in Column A.

Column A

_____For driving bolts or rivets out of holes.

_____For marking the location of holes to be drilled in metal.

_____To align bolt holes of parts for assembly.

_____For cutting "V" grooves in metal.

_____For cutting narrow grooves in metal.

_____For cutting the heads off rivets and for splitting nuts.

Column B

A. Pin punch.

B. Flat chisel.

C. Drift punch.

D. Diamond point chisel.

E. Center punch.

F. Cape chisel.

////////////////////

A   E   C and/or A   D   F   B

Frame 48

Select the correct answer:

Chisels and punches that have become mushroomed should be

A. used.

B. thrown away.

C. dressed on a grinding wheel.

////////////////////

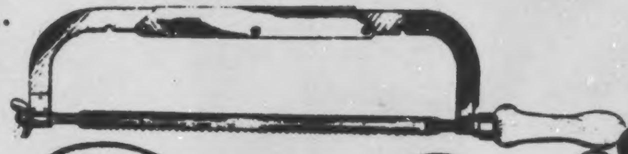
C

Frame 49

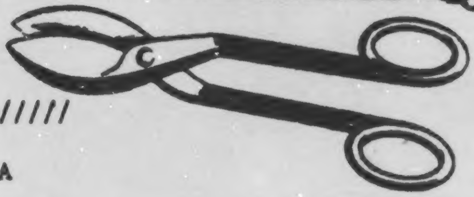
Match the items in Column B with the nomenclature listed in Column A.

Column A	Column B
_____Shears, metal cutting, hand, straight, 12 1/2-inch o/a.	A.
_____Frame, hand, hacksaw, adjustable, 3 5/8-inch throat, 8, 10, 12 inch blade capacity.	B.

A.



B.



////////////////////

B A

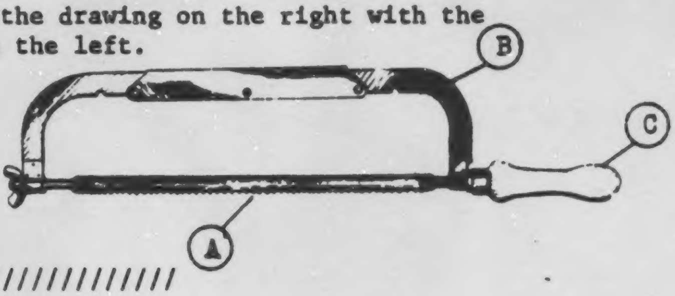
Frame 50

Match the items lettered in the drawing on the right with the parts of the hacksaw as listed on the left.

_____Frame.

_____Handle.

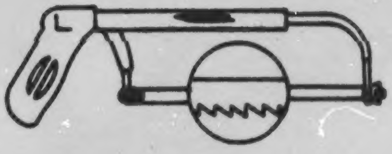
_____Blade.



////////////////////

B C A

Frame 51



Hacksaw blades are replaceable in the saw frame and the frames are adjustable to take various blade lengths. The drawing to the right illustrates the correct way to mount a blade in the frame.

When using the hacksaw, pressure should always be applied on the forward stroke. This is necessary because the cutting teeth of the hacksaw blade point forward. The teeth do not cut on the back stroke, therefore pressure should not be applied during the back stroke.

Answer each of the following statements as either true (T) or false (F).

_____When using a hacksaw, pressure is applied to the saw on the forward stroke only.

_____Hacksaw blades are replaceable.

_____A hacksaw frame is adjustable for different blade lengths.

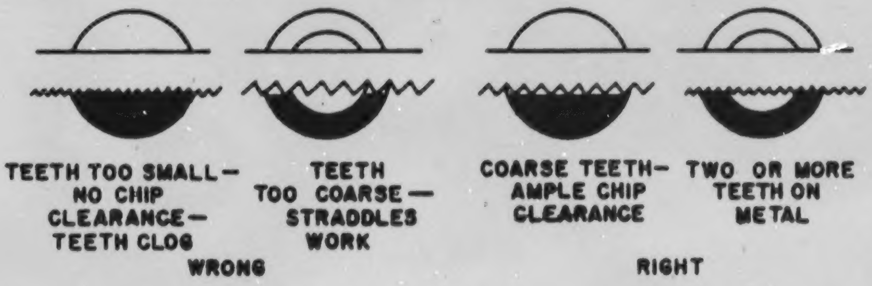
_____Hacksaw blades are installed in the frame with the teeth pointing backward (toward the handle).

////////////////////

T T T F

Frame 52

The drawings below illustrate the principles involved in selecting hacksaw blades that are the most suitable for a job. Study the drawings carefully and then answer each of the following statements as being either true (T) or false (F).


TEETH TOO SMALL— NO CHIP CLEARANCE— TEETH CLOG
TEETH TOO COARSE— STRADDLES WORK
WRONG
COARSE TEETH— AMPLE CHIP CLEARANCE
TWO OR MORE TEETH ON METAL
RIGHT

_____Hacksaw blades are available with different numbers of teeth per inch.

_____When cutting thin materials with a hacksaw a large toothed hacksaw blade should be used.

_____When cutting large stock with a hacksaw a small toothed hacksaw blade should be used.

////////////////////

T F F

Frame 53

Match the items listed in Column B with theuses listed in Column A.

Column A		Column B
_____Used for sawing metal.	A.	Tin snips.
_____Used for cutting sheet metal and similar materials.	B.	Hacksaw.

////////////////////

B A

Frame 54

Answer each of the following statements as being either true (T) or false (F).

_____When cutting a piece of tubing with a hacksaw you should use a small toothed blade.

_____When cutting a large bolt with a hacksaw you should use a large toothed blade.

_____Hacksaw blades should be installed in the saw frame with the teeth pointing toward the handle.

_____Hacksaw blades are available with different numbers of teeth per inch.

////////////////////

T T F T

Frame 55

Answer each of the following statements as either true (T) or false (F).

_____Tools should be kept clean and in good state of repair.

_____Moving parts of tools should be oiled periodically.

_____Always select the right tool for the job.

_____Tools should be wiped clean with a rag when you are through using them.

////////////////////

T T T T

PREPARE THE MAN

282
PROGRAMMED TEXT 3ABR47~~330~~-PT-103C
3ABR42133-PT-205C
3ABR47231-PT-202
3ABR47230-PT-108

Technical Training

General Purpose Vehicle Repairman
Aerospace Ground Equipment Repairman
Special Vehicle Repairman
Base Maintenance Equipment Repairman

8-9

SPECIAL TOOLS

2 January 1974

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-103C, 3ABR42133-PT-205C, 3ABR47231-PT-202, 30 July 1970.
OPR: TWS
DISTRIBUTION: X
TWS - 575; TTOC - 5

Designed For ATC Course Use

DO NOT USE ON THE JOB

189

Study Guides and Workbooks are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

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The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

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FOREWORD

This program was validated in 1964 by 30 students enrolled in the 3ABR47330 course at Chanute AFB. The text has trained approximately 3,000 students since 1964 and is considered to be valid.

OBJECTIVES

Upon completion of this programmed text you will be able to accomplish the following objectives with 80% accuracy.

1. Name the tools used to cut threads in a drilled hole.
2. Name the tool used to cut threads on round metal stock.
3. Name and describe the tool used to install and remove studs.
4. State the purpose of an impact wrench.
5. Name three types of torque wrenches.
6. Name the main parts of an electric drill.
7. Name the main parts of a bench grinder.

Frame 1.

"Coarse," "fine," and "extra fine" are descriptive terms that tell the mechanic which bolt to order for a specific job. Another descriptive phrase is "number of threads per inch." The number of threads per inch on a bolt varies with the purpose of the bolt.

QUESTION 1.

? ?

? Circle the letter below which identifies a true statement in the list given. ?

a. The number of threads per inch is determined by the diameter of the bolt.

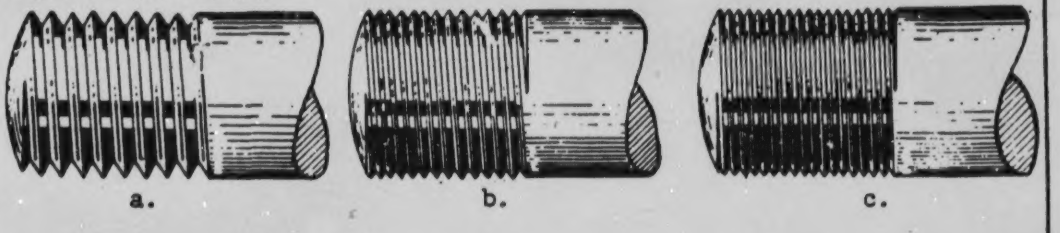
b. The purpose for which the bolt is to be used determines the number of threads per inch.

c. The length of the bolt determines the number of threads per inch.

? ?

NOTE: IF YOU ARE LOOKING FOR THE CONFIRMATION, IT WILL BE FOUND AT THE TOP OF THE NEXT FRAME ON THE OTHER SIDE OF THE SHEET.

The figure below illustrates three bolts of the same diameter. One has coarse threads, one has fine threads, and one has extra fine threads. In the spaces provided, write in the words which describe each of the bolts.



a. ______________ b. ________________ c. ______________

Frame 2.

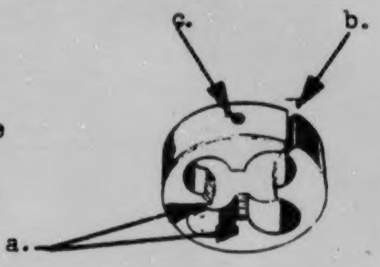
Answers for Frame 1:

Question 1. b.

a. coarse b. fine c. extra fine

The tool used to cut threads on round metal stock is called a "die." Since each size and type of thread requires the use of a specific die, they are made with a standard outside dimension in order to fit into one common handle. There are four cutting edges on the inside which cut the threads. Most dies are made with a split side and an adjusting screw which compensates for wear on the cutting edges.

In the accompanying figure, identify the split side, the adjusting screw, and the cutting edges. Write in the correct names in the spaces provided.



a. ______________________________

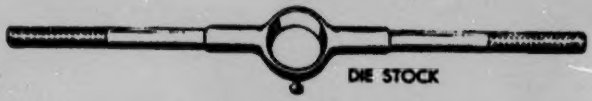
b. ______________________________

c. ______________________________

Answers for Frame 2:

- a. cutting edges.
- b. split side.
- c. adjusting screw.

We have said that dies are made with a standard outside diameter so that they may be used with a common handle. This handle is called a "die stock." It is constructed with a round center portion to receive the die, and a thumb screw is threaded into this portion to mate with a recess in the die to prevent the die from turning in the stock. There are two handles with knurled grips to turn the die on the round metal stock to be threaded. In the illustration below, note the various features just described.



Just as dies are used to cut threads on the outside of a bolt, so must some means be provided for cutting threads inside a drilled hole. The tool used for this purpose is called a "tap." There are three types of taps: the tapered tap, the plug tap, and the bottoming tap.

Frame 4.

QUESTION 2.

? ?

? Circle the letter below that identifies the true statement. ?

? a. Tapered taps are used for cutting threads in tapered holes. ?

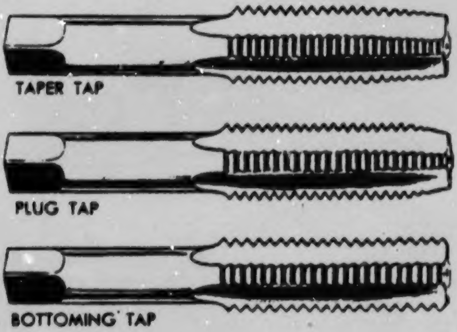
? b. If the drilled hole is too small, a tapered tap will enlarge it. ?

? c. Tapered taps are used for starting the threads in a drilled hole. ?

? ?

? ?

In the accompanying figure, the three types of taps are pictured. Note that the tapered tap has a very gradual taper for cutting threads by removing small bits of metal with each cutting surface. The plug tap has a very abrupt taper. It is designed to follow the tapered tap and thus will find the threads already partially cut. The bottoming tap is designed to cut threads all of the way to the bottom of a blind hole so it has no taper at all.



QUESTION 3.

? ?

? Which tap is used to start the threads in a drilled hole? ?

? ANSWER: ______________________________. ?

? ?

Answers to previous questions:

2. c. (Tapered taps are used for starting threads.
3. taper tap.

Sometimes it is necessary to cut threads inside a "blind hole" (one that is drilled into an otherwise solid piece of metal but does not go all of the way through it). In such cases, after starting the threads with the ____________ tap, we use a "plug" tap to cut all but the last few threads in the blind hole.

QUESTION 4.

? ?

? Circle the letter in front the true statement. ?

? a. Taps are used to cut threads inside a drilled hole. ?

? b. Taper taps are used for starting the threads inside a drilled ? hole.

? c. Plug taps are used for cutting all but the last few threads ? in a blind hole. ?

? d. All of the above statements are correct. ?

? ?

Frame 6.

Answers for Frame 5:

tapered

Question 4. d. (All the statements are true)

Since the use of taps may be new to you, perhaps it would be helpful to perform an additional exercise on the use of them. Fill in the blanks below.

a. Taper taps are used to ______________________________

____

b. Plug taps are used to ______________________________

____.

c. Bottoming taps are used to ___________________________

____

Frame 7.

Answers for Frame 6:

a. Taper taps are used the start the threads in a hole.

b. Plug taps are used to cut all but the last few threads in a blind hole.

c. Bottoming taps are used to cut threads to the bottom of a blind hole.

? ?

SELF TEST

As a review, answer the following questions, then check with the answers given on the top of the next frame. If you did not answer all of the questions correctly, go back to that part of the program where the material was covered, review the material, correct your mistake, and only then proceed with the program.

QUESTION 5. The number of threads per inch on a bolt varies with ______________________________.

QUESTION 6. The tool used to cut threads inside a drilled hole is called a ______________________________.

QUESTION 7. The tool used to start the threads inside a drilled hole is a ______________________________.

QUESTION 8. The tool which cut threads to the bottom of blind hole is a ______________________________.

QUESTION 9. The tool which cuts threads on the outside of a bolt is a ______________________________.

QUESTION 10. The handle for the tool in Question # 5 is called a ______________________________.

? ?

Frame 8.

Answers to SELF TEST:

5. purpose of the bolt.
6. tap.
7. taper tap.
8. bottoming tap.
9. die.
10. die stock.

In addition to knowing the type of tap to be used in a given situation, it is also necessary to know the correct size. Taps are sized according to the size of the bolt that will screw into the finished threaded hole. This bolt size, then, is determined by the diameter of the bolt and the number of threads per inch.

QUESTION 11.

? ?

? Circle the correct statement below. ?

? a. Taps are sized according to the size of the drilled hole. ?

? b. Taps are sized according to diameter and length of the threaded part. ?

? c. Taps are sized according to the length and number of threads per inch. ? ?

? d. Taps are sized according to diameter and number of threads per inch. ? ?

? ?

Answer to Question 11: d.

QUESTION 12.

? ?

? Once more! How is the size of the tap determined? (Write your answer in the blank spaces provided below.) ?

? ?

? ____ ?

____

? ____. ?

? ?

Sometimes the threads on a stud or bolt become partially damaged and a replacement is not readily available. To repair the threads, so that a nut may be installed, a tool called the "thread restorer" is used. This tool is shaped very much like a file but the teeth are spaced to correspond with the threads on a bolt or stud. The extent of damage, amount of torque on the bolt, and whether or not it is a critical installation are all determining factors on whether to use the thread restorer or replace the bolt.

QUESTION 13.

? ?

? Circle the letter in front of the correct statement below. ?

? a. Slightly damaged threads may be repaired with a file. ?

? b. Slightly damaged threads may be repaired with a thread restorer. ?

? c. Slightly damaged threads always require replacement of the bolt. ?

? d. A thread restorer should never be used. ?

? ?

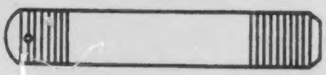
Frame 10.

Answers to previous questions:

12. The size of a tap is determined by the diameter and the number of threads per inch.

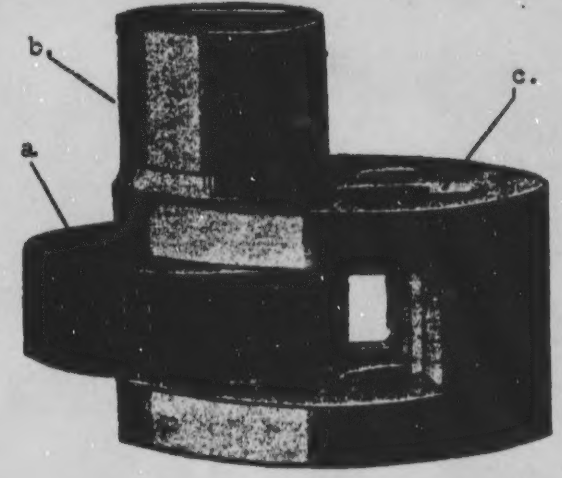
13. b. (Slightly damaged threads may be repaired with a thread restorer.)

A stud is a bolt with threads on both ends. It has no head, therefore it requires a special tool to remove or install it. As you will note from the accompanying illustration, a typical stud has an unthreaded portion in the center. This unthreaded portion is the area used when installing or removing a stud. The tool which is used for installing and removing studs will be shown in the next frame of this program.



Frame 11.

Studs are bolts with threads on both ends. They are often used in various parts of automobiles. Because they have no head they are more difficult to install or remove than are bolts with heads. A special tool, called a stud wrench, has been devised to install or remove studs with minimum damage to the stud. The stud wrench is designed to fit most common sizes of studs.



In the figure shown above, identify the eccentric-mounted gripping cam, the drive adapter, and the stud receiver. Label the parts of the drawing in the spaces provided below.

a. ______________________________

b. ______________________________

c. ______________________________

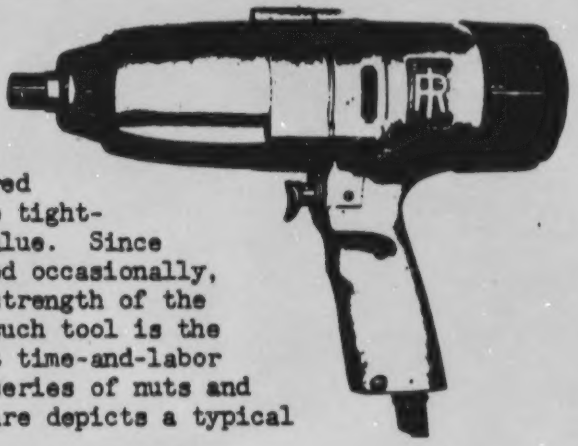
Frame 12.

Answers to Frame 11:

a. gripping cam.

b. drive adapter.

c. stud receiver.



Many parts of automobiles and trucks, as well as other mechanical devices, are secured with nuts and bolts which are tightened to a very high torque value. Since these parts have to be removed occasionally, a tool which multiplies the strength of the mechanic was required. One such tool is the impact wrench. It is a great time-and-labor saver when used to remove a series of nuts and bolts. The accompanying figure depicts a typical impact wrench.

QUESTION 14.

? ?

? Circle the correct statement below. ?

? a. The impact wrench is used solely for hammering. ?

? b. The impact wrench multiplies the strength of the mechanic. ?

? ?

Answer to Question 14: b was the correct choice.

The impact wrench may be used in many applications with any of the drives, extensions, or fittings used with the socket set. Probably the most common use of the impact wrench is for removing and installing auto and truck wheel lug nuts. The wrench can be used for either left-hand or right-hand operation by merely turning a switch or lever. The impact wrench also incorporates an adjustable torque-setting fitting to prevent over-torquing the nut or bolt being installed.

QUESTION 15.

? ?

? Which of the following statements are correct? ?

? a. Impact wrenches are for right-hand use only. ?

? b. Impact wrenches may be used in either right or left hand operation. ?

? ?

c. There is a torque-setting adjustment on impact wrenches.

? ?

d. The operator must be careful not to over-torque a nut or bolt.

? ?

? ?

Frame 14.

Answers to Question 15: b and c are both correct statements.

Impact wrenches may be driven be either air pressure or electricity. Because of the extreme pressures that can be applied with the impact wrench, it is advisable to use heavy-duty, thick-walled, six-point sockets with them. The ordinary twelve-point sockets are easily split by the heavy vibration of the impact wrench. Special impact wrench sockets are available and can also be used.

QUESTION 16.

? ?

? Which of the following statements is correct? ?

? a. Impact wrenches are operated by air pressure and hydraulic pressure. ?

? b. Vacuum pressure and electricity are used to operate the impact wrench. ?

? c. Electricity and air pressure are the two methods of operation. ?

? d. Electricity and hydraulic pressure are used to operate the impact wrench. ?

? ?

Answer to Question 16: c. was the only correct statement.

QUESTION 17.

? ?

? The correct sockets to be used with the impact wrench are the ?

? a. four-point socket or a special socket. ?

? b. six-point socket or a special socket. ?

? c. eight-point socket or a special socket. ?

? d. twelve-point socket or a special socket. ?

? ?

Whenever two pieces of metal are bolted together, a specified amount of "torque" or twisting force is designated for the bolts. This "torque" is measured in inch-pounds if the force is light or if the bolts are of small diameter. Torque is measured in foot-pounds if the force is great or if the bolts are of large diameter.

QUESTION 18.

? ?

? Which of the following statements are correct? ?

? a. Torque is measured in pounds per square inch. ?

b. The hyphenated word "inch-pounds" is used to designate torque.

? c. When torque is large, the proper designation is foot-pounds. ?

? d. Torque is measured in pounds per square foot. ?

? ?

Frame 16.

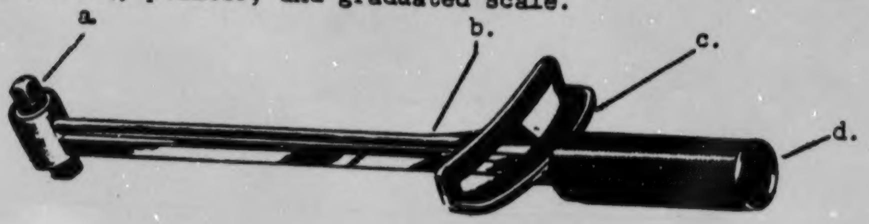
Answers to previous questions:

17. b.

18. b. and c. are both correct statements.

Early attempts to measure the torque being applied to a bolt included the use of a spring-type scale attached to a handle of predetermined length, such as 12 inches. Since this was a cumbersome device, a special wrench utilizing a socket drive, a handle with predictable bend characteristics, a pointer, and a graduated scale was devised.

In the figure below, a torque wrench of the type described above is illustrated. In the spaces provided below, identify the handle, socket drive, pointer, and graduated scale.



a. ______________________ c. ______________________

b. ______________________ d. ______________________

Answers to Frame 16:

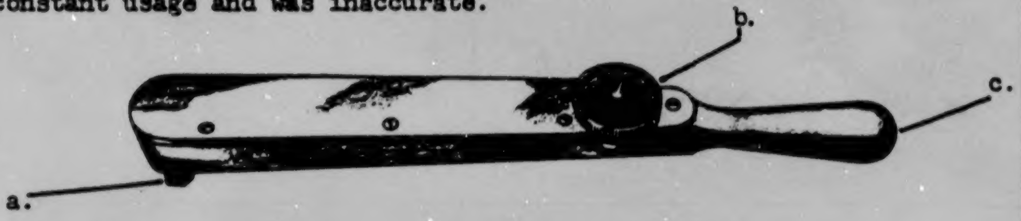
a. socket drive.

b. pointer.

c. graduated scale.

d. handle.

Another design used in earlier torque wrenches is that shown in the figure below. This design incorporated a dial indicator calibrated in inch-pounds or foot-pounds of torque. This design protected the vital parts from damage, but it was no more satisfactory than the simpler type because the enclosed linkage became loosened through constant usage and was inaccurate.



Using the figure above, identify the socket drive, the dial indicator, and the handle.

a. ______________________________

b. ______________________________

c. ______________________________

Frame 18.

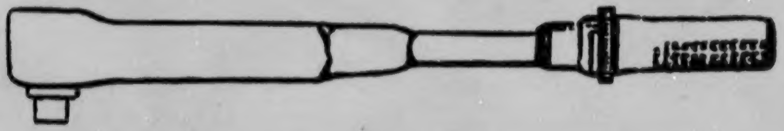
Answers to Frame 17:

a. socket drive.

b. dial indicator.

c. handle.

Both of the torque wrenches mentioned previously must be read while the socket or adapter is being turned. This is often unhandy because of the location of the bolt being tightened, poor lighting, etc. For this reason, as well as the fact that constant use caused the earlier types to become erratic, a new type of wrench was developed. This type is called a "breakaway" torque wrench. One model of the breakaway torque wrench is shown in the figure below.



The breakaway torque wrench is so named because it gives a slight "break" or slip when the preset torque value is reached. This feature allows for use of the wrench in any position or under any lighting condition and it insures accurate torque application. The wrench does not actually "break away" from the nut or but; rather, it slips just enough to allow the operator to feel and hear a "click."

QUESTION 19.

? ?

? Circle the letter in front of the true statement below. ?

? a. All torque wrenches are easy to use. ?

? b. The dial-indicating torque wrench is the most accurate. ?

? c. The breakaway type torque wrench can be used in any position. ?

? d. The pointer-graduated scale type torque wrench is the most accurate. ?

? ?

? ?

Frame 20.

Answer to Question 19: c.

? ?

SELF TEST

The following questions are designed to help you review the information given up to this point concerning torque wrenches. Write your answers in the spaces provided.

20. How is torque measured? ______________________________
______________________________.

21. What three types of torque wrenches have been mentioned?
______________________________, ______________________________,
AND ______________________________.

22. What is one advantage of the later type torque wrenches? ______
______________________________.

23. What parts are common to all torque wrenches? ______________
____

24. Why must torque wrenches be used? ______________________
______________________________.

? ?

Answers to SELF TEST questions:

20. Torque is measured in inch-pounds or foot-pounds.
21. Pointer and graduated scale, dial indicating, and breakaway.
22. It can be used in any position and in any light.
23. Socket drive, indicator, and handle.
24. To insure that the correct amount of force is applied to EACH nut or bolt.

The older types of torque wrenches, such as the pointer-and-scale and the dial-indicating are still in use in some shops. However, the Air Force has declared them to be obsolete for aircraft use so it is safe to assume that they will be discarded by other activities as well. On the other hand, the breakaway type torque wrench has received almost universal acceptance because of its accuracy and reliability.

QUESTION 25.

? ?

? Circle the letter in front of the correct statements below. ?

a. All types of torque wrenches are acceptable for Air Force use.

? b. Only the breakaway type torque wrench has universal acceptance. ?

? c. The breakaway torque wrench is more accurate and reliable than the others. ?

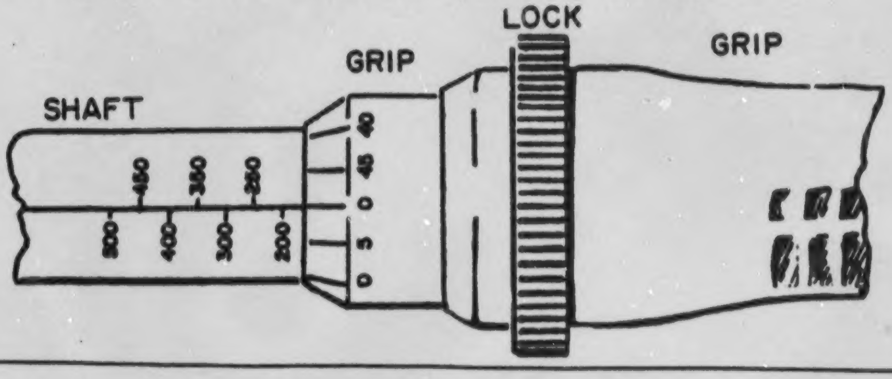
? d. The dial-indicating type torque wrench is less susceptible to damage. ?

? ?

Frame 22.

Answers to Question 25: b. and c. are the correct statements.

Since the breakaway torque wrench is the one most commonly used, we will concentrate on learning more about it. Unlike the pointer-and-scale, or the the dial-indicating torque wrenches, which must be read while in use, the breakaway type wrench is preset to the desired torque to be applied. In the illustration below, note the various parts which, along with the socket drive, make up the wrench.



QUESTION 26.

? ?

? There are two scales which must be used to set the torque on the ?
wrench. One scale is located on the shaft and the other scale is on
? the ________________. ?

? ?

Answer to Question 26: grip

QUESTION 27.

? ?

? By reference to the figure in Frame 22, you can see that the scale ?
on the shaft is stamped in increments of _____ inch-pounds (or foot-
? pounds if it is a heavy-duty wrench). ?

? a. 25. ?
b. 50.
? c. 75. ?
? d. 100. ?

? ?

QUESTION 28.

? ?

? By reference to the figure in Frame 22, you can see that the scale ?
on the grip is stamped around the grip and reads from 0 to 49. One
? full turn of the grip would give an increase (or decrease) of ______ ?
inch-pounds (or foot-pounds).
? ?
a. 25.
? b. 50. ?
c. 75.
? ?
d. 100.
? ?

? ?

Frame 24.

Answers to previous questions:

27. b.
28. b.

The breakaway type torque wrench incorporates an additional feature to insure accuracy in applying torque to a bolt. This is a locking device, which on some wrenches is turned to affect the lock on the grip and in others is slid along the grip to engage a pawl or slot in the shaft. In either case, the grip is prevented from turning while the wrench is in use.

QUESTION 29.

? ?

? Circle the letter in front of the correct statements below. ?

? a. All torque wrenches contain a locking device. ?

? b. All types of torque wrenches are acceptable for Air Force use. ?

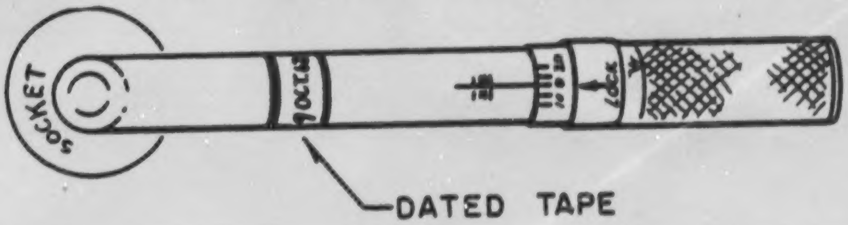
? c. Only the breakaway types of torque wrenches have a locking feature. ?

? d. The pointer-and-scale and the dial-indicating types are obsolete for aircraft use. ?

? ?

Answers to Question 29: c. and d. are the correct statements

Torque wrenches are handled like precision instruments in the Air Force. This includes storage in a separate container and regular, frequent calibration. Torque wrenches which are used on aircraft, and other critical equipment, are calibrated every 30 days. At the time of calibration a dated date is fastened to the torque wrench to remind the mechanic of the next due date for calibration. In the drawing below, note the placement of the dated tape.



QUESTION 30.

? ?

? Circle the letter in front the the correct statements below. ?

? a. Torque wrenches may be handled like other tools. ?

? b. Torque wrenches are date-taped to insure calibration at the proper time. ?

? c. The dated tape on a torque wrench tells when it was purchased. ?

? d. Torque wrenches must be treated like precision instruments. ?

? ?

Frame 26.

SELF TEST

Answer the following questions on torque wrenches, then check your responses with those given on the next page. Careful, now, no fair "peekin" !

31. Why are torque wrenches used?

32. Which torque wrenches are considered obsolete?

33. How is torque measured?

34. How much is the torque increased by turning the grip one complete turn?

35. What feature prevents the torque value of the wrench from changing?

36. Why is a dated tape attached to a torque wrench?

37. Where are torque wrenches kept?

38. How often are torque wrenches calibrated?

39. How does the operator know when the proper torque is reached when using the breakaway-type torque wrench?

40. Name two parts common to all torque wrenches?

Answers to SELF TEST questions:

31. Torque wrenches are used to insure the application of an exact force.

32. The pointer-and-scale and the dial-indicating types are considered to be obsolete.

33. Torque is measured in inch-pounds or foot-pounds.

34. One complete turn of the grip increases (or decreases) the torque 50 inch-pounds.

35. The breakaway torque wrench has a lock which prevents the torque from changing.

36. To indicate when the wrench was last calibrated and to remind the operator when it is due.

37. Torque wrenches are kept in separate containers to prevent damage.

38. Torque wrenches are calibrated every 30 days.

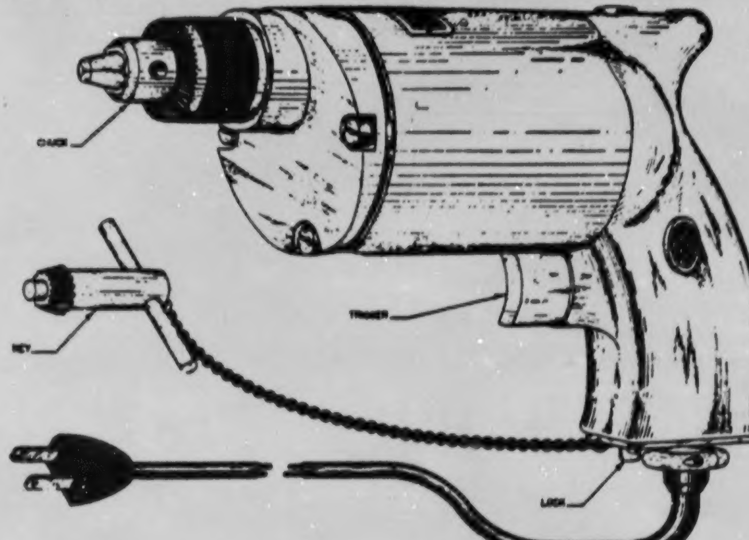
39. When using the breakaway torque wrench, a "click" will be felt and heard.

40. The two parts which are common to all torque wrenches are the socket drive and the handle or the grip.

If your answers do not agree with these in fact (your wording may be slightly different), review the portion of this program which covers the questions you missed before proceeding with the next portion of the program.

Frame 28.

One of the most useful tools available to the mechanic is the electric drill. Theprincipal use of the electric drill is for boring or drilling holes in metal. Drills commonly used in the shop are of the 1/4 inch, 3/8 inch, or 1/2 inch capacity It is never advisable to exceed the rated capacity of an electric drill. Such a practice usually results in burning up the drill motor. For shop use, hardened steel drill bits are used with the electric drill. As you can see from the picture below, the main parts of the portable electric drill are the motor, chuck, handle, trigger, trigger lock, and chuck key



QUESTION 41.

? ?

? Circle the letter before the correct statement below. ?

? a. The best tool for drilling holes in metal is the electric drill?

? b. The capacity of an electric drill should never be exceeded. ?

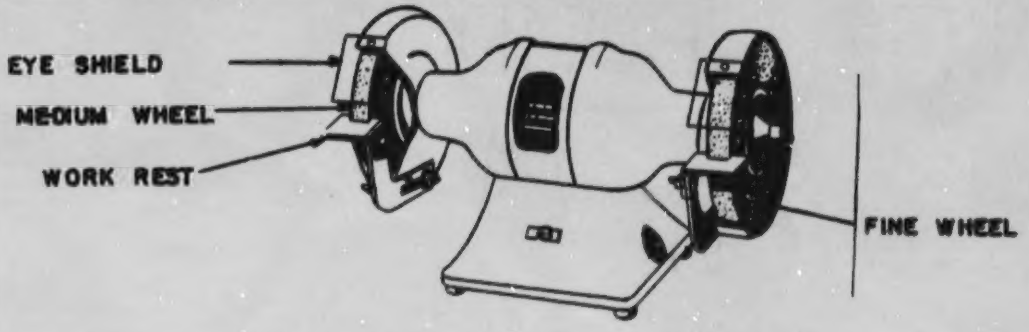
? c. Hardened steel drill bits are best for use with the electric drill. ?

? d. All of the above statements are true. ?

? ?

Answer to Question 41: d. was the best choice of answers.

Another power tool found in most shops is the bench grinder. A typical bench grinder is shown in the illustration below. Note that the main parts of the bench grinder are the stand, motor, grinding wheels, work rest, and eye shield. The grinding wheels should always be checked for cracks before starting the motor.


EYE SHIELD
MEDIUM WHEEL
WORK REST
FINE WHEEL

Frame 30.

The bench grinder operates most efficiently at maximum RPM. Excessive pressure on the grinding wheel causes the motor to overheat and the metal being sharpened to burn. The grinding action is the result of friction between the wheel and the metal; so the faster the rotation of the grinding wheel, the greater the friction.

QUESTION 42.

Circle the letter in front of the correct statement below.

a. Pressing hard on the grinding wheel increases its efficiency.
b. Too much pressure on the wheel will cause the metal to burn.
c. If the motor turns too fast, it will overheat.
d. Friction helps cool the metal.

Answers to Question 43: b., c., and d. are all correct statements.

Answer to Question 42: b. was the correct answer.

The bench grinder usually has two stones or wheels; one made of fine grit and the other of coarse grit, which grit is held together by a strong adhesive. An electric motor (usually rated at 1/2 horsepower) turns the stones at a high rate of speed. The material to be sharpened, smoothed, or reduced in size is held on the tool rest and pressed against the rotating stone.

QUESTION 43.

? ?

? Circle the letter in front of the correct statement(s) below. ?

? a. Grinding wheels are cut out of solid stone. ?

? b. Bench grinders are used to sharpen chisels, punches, and drill bits. ?

? c. The material to be "ground" is pressed against the rotating wheel. ?

? d. The stones are turned at a high rate of speed. ?

? ?

Note: Refer to the bottom of Frame 30 to find the answer(s) to the question above.

PROGRAMMED TEXT
3ABR47232-PT-104B
3ABR47230-PT-108A
3ABR47231A-PT-103B
3ABR47231B-PT-103B
3ABR47231C-PT-103B
3ABR47231D-PT-103B

Technical Training

8-9

General Purpose Vehicle Mechanic
Base Vehicle Equipment Mechanic
Special Vehicle Mechanic
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)
(Towing and Servicing Vehicles)

MEASURING DEVICES

17 February 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

FOREWORD

This programmed text was developed for use in the 3ABR47330, Automotive Repairman course in 1965. It was validated with students from the course, 90% of whom achieved the objectives as stated. The text has been used for over four years, with approximately 3,000 students, and is considered valid.

OBJECTIVES

When you have completed this programmed text, you will be able to:

1. Match a list of measuring tools with a list of their proper uses.
2. Identify the unit of measurement for each of a list of gages.
3. Match a list of decimals with a list of words which describe the numbers.
4. From a list, identify the parts of a micrometer.
5. Record the correct measurements shown on a drawing of two steel rules.
6. Match a list of measuring tools with a list of correct names.
7. Record the correct readings of four micrometers, from drawings.

INSTRUCTIONS

In this programmed text you will be given information and then directed to solve problems. The correct answers for the problems will be at the top of the page following the questions. For maximum learning, solve the problem and check it over before looking at the "school solution." If you are in error, go over your work until you find why you were wrong, before proceeding to the next frame.

Supersedes 3ABR47330-PT-104B, 1 August 1974.
OPR: TWS
DISTRIBUTION: X
TWS - 300; TTVGC - 1

Frame 1.

The five parts common to all outside micrometers are: frame; anvil; barrel; spindle; and thimble.

The half-moon shaped part of the micrometer is the frame.

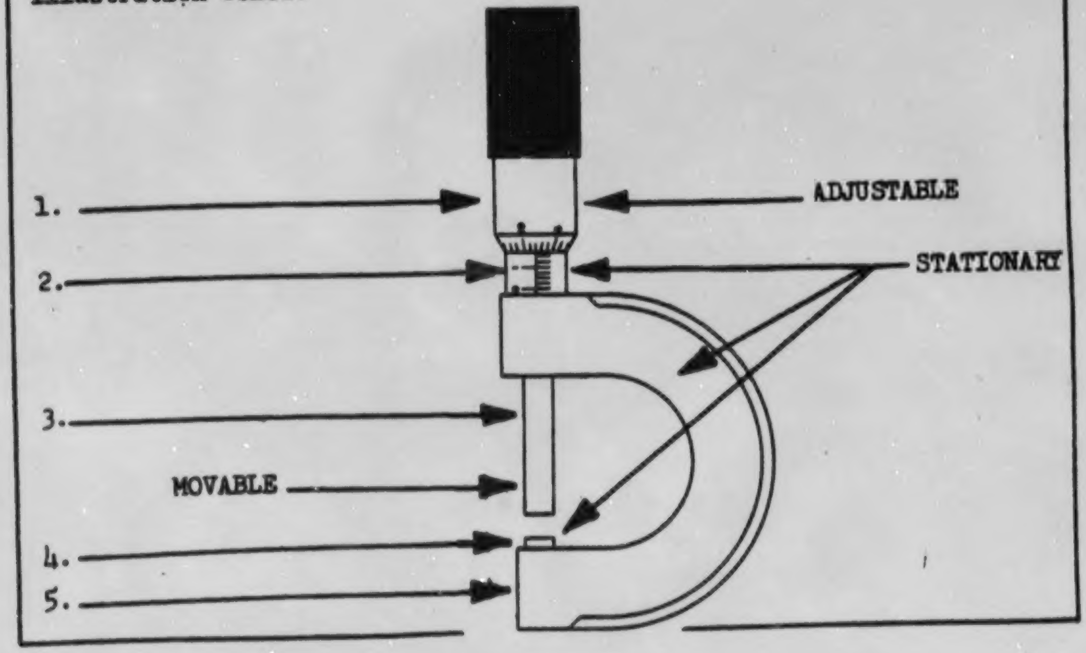
The non-movable measuring surface is the anvil.

The extension connected to the opposite end of the frame from the anvil is the barrel.

The movable measuring surface protruding from the barrel is the spindle.

The adjusting device surrounding the barrel is the thimble.

Correctly label the five parts of the micrometer indicated on the illustration below.



Frame 2.

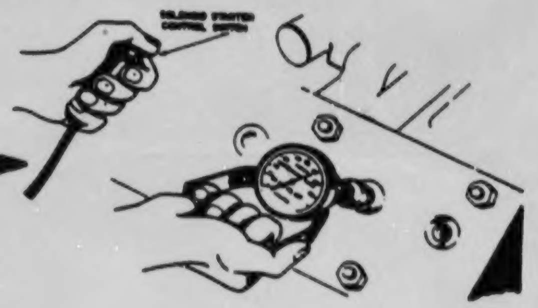
Answers for Frame 1:

1. Thimble
2. Barrel
3. Spindle
4. Anvil
5. Frame

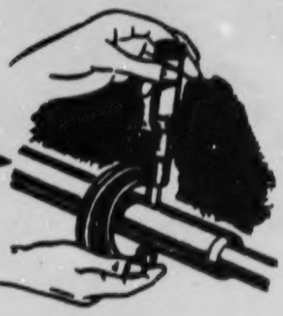
The outside micrometer is used to measure the diameter and roundness of objects.

6. Circle the letter next to the diagram below that shows the micrometer in use.

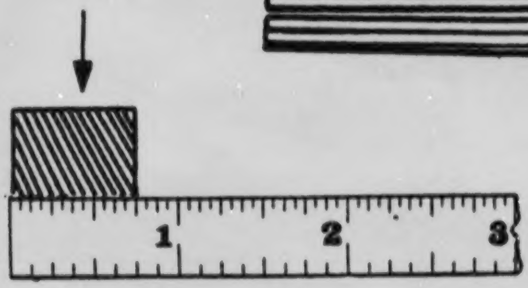
A.



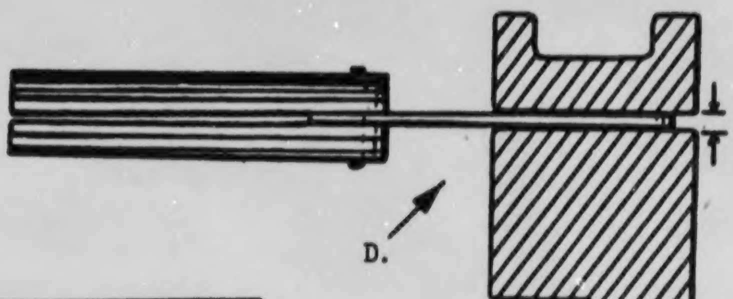
B



C.



D.



Answer for Frame 2: B. showed the micrometer in use.

QUESTION 7.

? ?

? Circle the letter that identifies the corrrect answer below. ?

? The outside micrometer is used to measure ?

? a. small linear distances. ?

b. the clearance between two objects.

? c. end play, back lash, and alignment. ?

? d. the diameter and roundness of objects. ?

? ?

Place the letter which identifies each part of the micrometer into the space provided beside the name of the part.

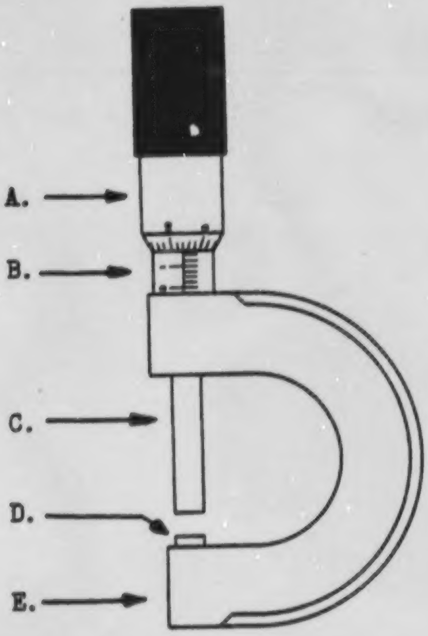
8. Spindle _____

9. Thimble _____

10. Frame _____

11. Barrel _____

12. Anvil _____



Frame 4.

Answers for Frame 3:

Question 7. d.
8. C
9. A
10. E
11. B
12. D

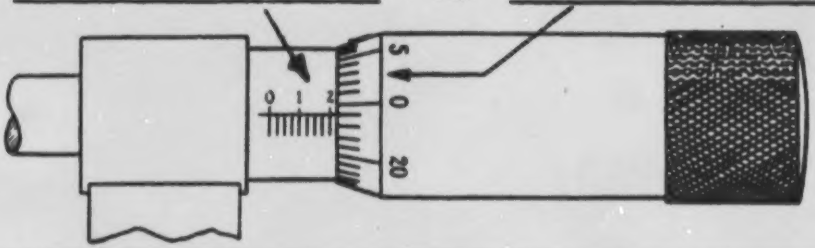
The outside micrometer has two scales called the barrel and thimble scales.

The barrel scale has a line running lengthwise on the barrel. The division marks are spaced horizontally along this line.

The thimble scale has divisions spaced vertically (around the thimble.

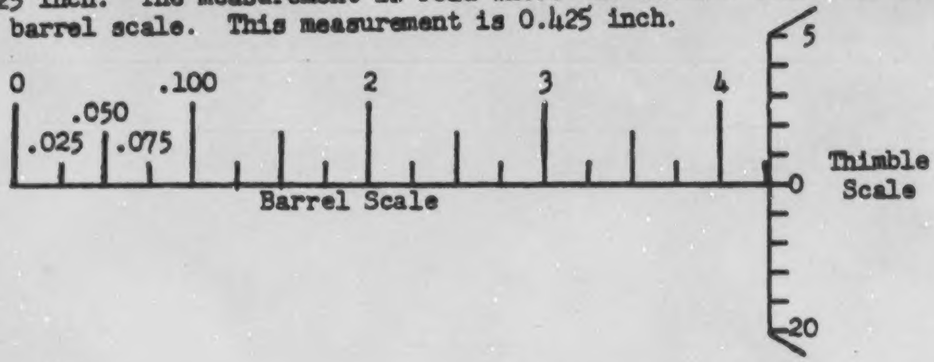
Label the two micrometer scales shown on the diagram below.

13. ______________________ 14. ______________________



Frame 5.

Ask your instructor for an outside micrometer. Note the thimble and barrel scale construction. The barrel scale indicates measurements to the nearest twenty-five thousandths (0.025) of an inch. Observe in the diagram below that each mark on the barrel scale equals 0.025 inch. The measurement is read where the thimble scale meets the barrel scale. This measurement is 0.425 inch.



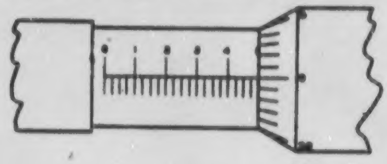
Using the micrometer given to you, set the barrel scale of the micrometer to 0.500 inch. After setting your micrometer, compare your setting with that shown for number 15 on the top of the next page.

Set your micrometer barrel scale to 0.375, 0.250, and 0.125. After setting the micrometer on each setting, compare your work with that shown for numbers 16, 17, and 18, respectively, on the top of the next page.

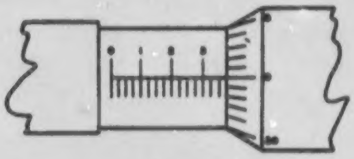
Frame 6.

Solutions for Frame 5:

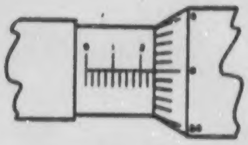
15.



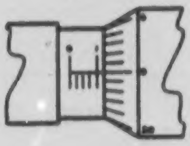
16.



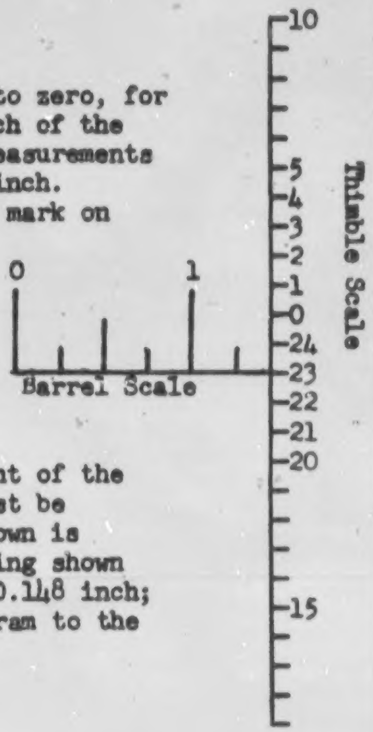
17.



18.



One full turn of the thimble scale (zero to zero, for example) will expose or cover 0.025 of an inch of the barrel scale. The thimble scale indicates measurements to the nearest one-thousandth (0.001) of an inch. Observe on the figure to the right that each mark on the thimble scale equals 0.001 inch. The measurement is read where the thimble scale meets the horizontal line on the barrel scale. The thimble scale shown has been stretched out so as to show the entire scale.



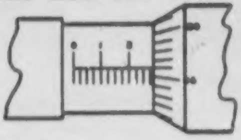
In order to obtain the complete measurement of the barrel and thimble scales, these readings must be added together. The barrel scale reading shown is equal to 0.125 inch. The thimble scale reading shown is o.023 inch. The sum of 0.125 + 0.023 is 0.148 inch; therefore, the measurement shown on the diagram to the right is 0.148 inch.

Set your micrometer to 0.159. After that, compare your micrometer setting to the figure shown on the top of the next frame after the number 19.

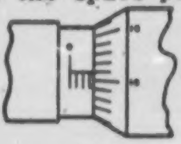
Set your micrometer to 0.342, 0.393, and 0.871. Compare each of your micrometer settings to those shown at the top of the next frame after numbers 20, 21, and 22 respectively.

Record the micrometer readings shown on the illustrations below, to the nearest 0.001 inch, in the space provided below each figure.

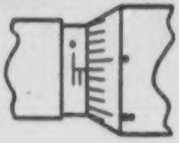
23.



24.



25.

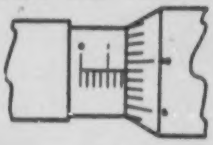


Return your micrometer to the instructor after successfully completing this part of the exercise.

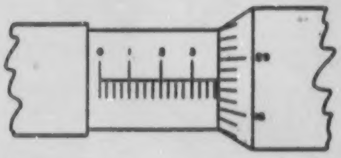
Frame 8.

Answers for Frame 7:

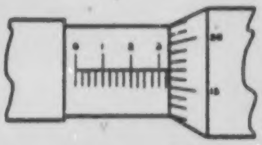
19.



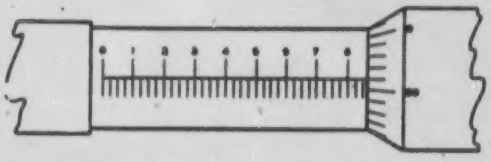
21.



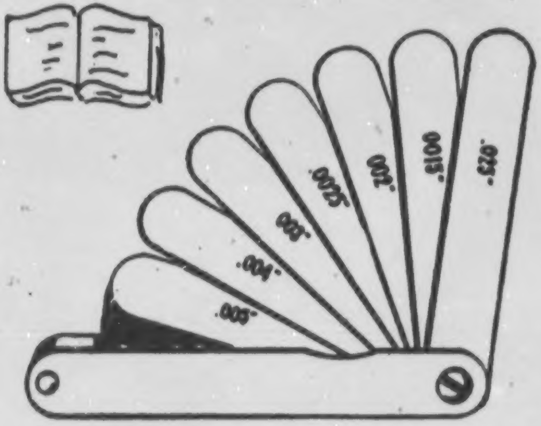
20.



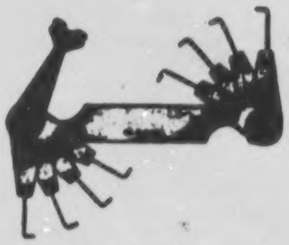
22.



23. 0.291 24. 0.086 25. 0.049


.005"
.004"
.003"
.0025"
.002"
.0015"
.025"

Thickness gauge



Spark plug gauge

The thickness gauge is used to measure the clearance between objects.

The spark plug gauge is used to measure and adjust the spark plug electrode gap.

QUESTION 26.

? ?

? Circle the letter which identifies the correct answer to the statement given below. ?

?

Either a thickness gauge or a spark plug gauge may be used to

- a. measure spark plug electrode clearance.
- b. measure valve stem to rocker arm clearance.
- c. adjust spark plug electrode clearance.
- d. adjust valve stem to rocker arm clearance.

? ?

QUESTIONS 27 through 29.

? ?

? Match the measuring tools to their uses by recording the letter that? identifies each use in the space provided beside the name of each ? measuring tool.

? 27. Outside micrometer ______

? 28. Spark plug gauge ______

? 29. Thickness gauge ______

a. Used to measure and adjust spark plug electrode gap. ?

b. Used to measure the diameter and roundness of objects. ?

c. Used to measure the clearance between two objects. ?

? ?

Frame 10.

Answers to previous questions:

26. a.
27. b.
28. a.
29. c.

The thickness gauge consists of a number of leaves, each having a different thickness.

Each leaf of a thickness gauge is stamped with a number to indicate its thickness in terms of thousandths of an inch.

The spark plug gauge consists of several wires having various diameters.

Numbers are stamped on the spark plug gauge to indicate the diameter of each wire.

Each number stamped on the thickness gauge and on the spark plug gauge consists of three numbers preceeded by a decimal point.

To read the numbers stamped on thickness and spark plug gauges, read the number as it appears without the decimal and then add the words "thousandths of an inch."

QUESTIONS 30 through 33.

? ?

? Match the numbers to the word descriptions by recording the letter that identifies each word description in the space provided beside each number. ?

30.	0.035 ______	a.	Twenty-one thousandths.
31.	0.021 ______	b.	Nine thousandths.
32.	0.900 ______	c.	Thirty-five thousandths.
33.	0.009 ______	d.	Nine hundred thousandths.

? ?

Frame 11.

Answers to Questions 30 through 33:

30. c.
31. a.
32. d.
33. b.

QUESTIONS 34 through 37.

? ?

? Record the letter that identifies each decimal number in the space provided beside the words which describe that number. ?

?

34. Twenty thousandths. ______ a. 0.012.
35. Two hundred thousandths. ______ b. 0.002.
36. Two thousandths. ______ c. 0.020.
37. Twelve thousandths. ______ d. 0.200.

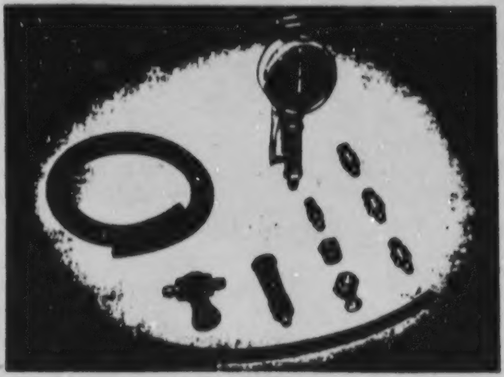
? ?

Frame 12.

Answers to Questions 34 through 37:

34. c.
35. d.
36. b.
37. a.

The vacuum gauge is used to measure the amount of vacuum created by the engine or the fuel pump.



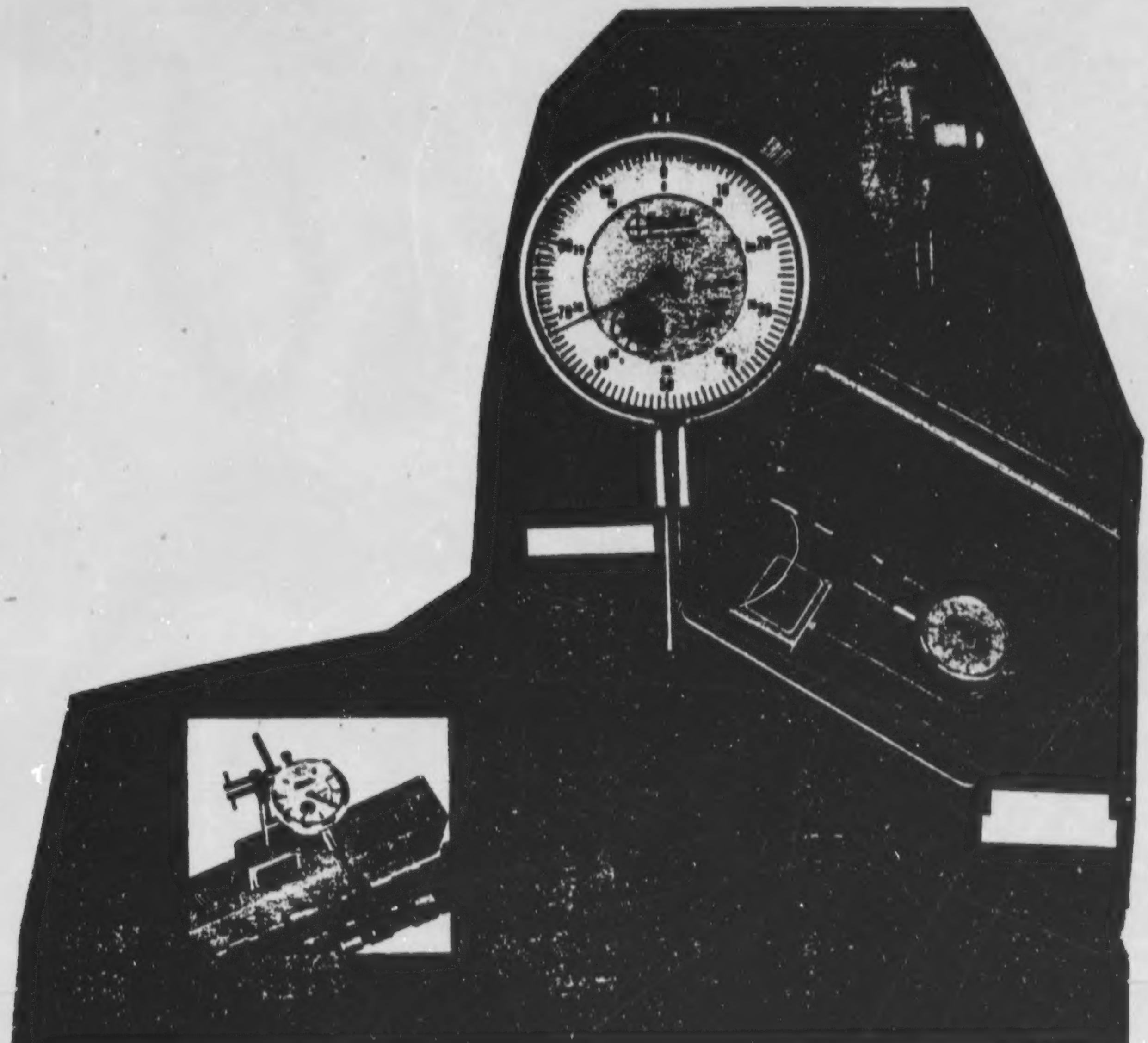
Vacuum and fuel pump tester shows overall engine performance and fuel pump pressure under true operating conditions. This tester shows fuel pump condition and gives vacuum and pressure readings. The scale is calibrated 0-30 inches of vacuum and 0-15 lbs pressure.

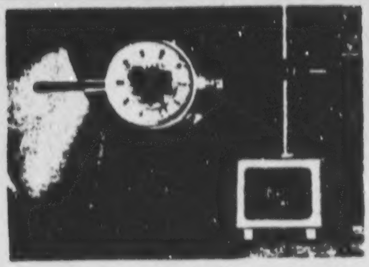
Pressure gauges are used to measure the amount of pressure created in air and hydraulic brake systems, fuel pumps, cooling systems, and automatic transmissions.

The compression gauge is used to measure the amount of pressure created in the cylinders of an engine.

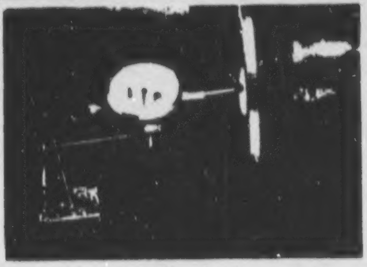
Compression tester. Insert the head in the spark plug opening and it automatically seals itself when the engine is cranked.

The dial indicator is used to measure end play, backlash, taper or wear, alignment, and out of roundness in thousandths of an inch.

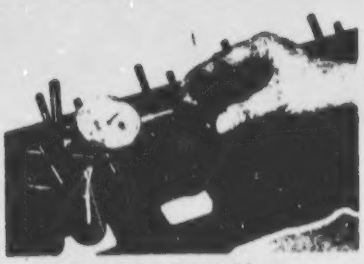




Testing flywheel runout



Checking disc brake runout



Checking valve guide wear

Frame 14

QUESTIONS 38 through 41.

Match the gauges to their uses below by recording the letter that identifies each gauge in the space provided beside the appropriate use.

38. Used to measure the amount of pressure created in air brake systems, hydraulic brake systems, fuel pumps, cooling systems, and automatic transmissions. ____.

39. Used to measure the amount of vacuum created by the engine and fuel pump. ____.

40. Used to measure end play, backlash, taper or wear, alignment, and out of roundness in thousandths of an inch. ____.

41. Used to measure the amount of pressure in the cylinders of an engine. ____.

a. Vacuum gauge.

b. Dial indicator.

c. Compression gauge.

d. Pressure gauge.

Answers to Questions 38 through 41:

38. d.
39. a.
40. b.
41. c.

Atmospheric pressure, the air around us, exerts a pressure of 14.7 pounds per square inch (PSI) at sea level.

A vacuum is a space where the pressure is less than atmospheric pressure.

One PSI exerted on a tube containing a column of mercury one inch in diameter, will raise the column of mercury 2.0369 inches; therefore, one PSI is equal to 2.0369 inches of mercury.

The unit of measurement of a vacuum gauge is inches of mercury.

The unit of measurement of compression and pressure gauges is pounds per square inch (PSI).

The unit of measurement of a dial indicator is thousandths of an inch.

QUESTIONS 42 through 44.

? ?

? Match the measuring tools to their typical units of measurement by recording the letter that identifies each tool in the space provided beside the appropriate unit of measurement below. ?

? 42. 15 inches. ______ a. Compression and pressure gauges. ?
? 43. 130 PSI. ______ b. Dial indicator. ?
? 44. 0.010. ______ c. Vacuum gauge. ?

? ?

Frame 16.

Answers to Questions 42 through 44.

42. c.

43. a.

44. b.

QUESTIONS 45 through 47.

? ?

? Record the letter that identifies each gauge in the space provided ?
beside the appropriate unit of measurement below.
? ?

45. Unit of measurement is thousandths of an inch. _____ ?

46. Unit of measurement is inches of mercury. _____ ?

47. Unit of measurement is pounds per square inch. _____ ?

a. Pressure and compression gauges. ?

b. Vacuum gauges. ?

c. Dial indicator. ?

? ?

Answers to Questions 45 through 47.

45. c.

46. b.

47. a.

QUESTIONS 48 through 51.

? ?

Match the measuring tools to their uses by recording the letter which identifies each use in the appropriate space provided beside the name of each measuring tool.

48. Vacuum gauge. ______

49. Compression gauge. ______

50. Dial indicator. ______

51. Pressure gauge. ______

a. Used to measure end play, backlash, taper or wear, alignment, and out of roundness in thousandths of an inch.

b. Used to measure the amount of pressure in brake systems, fuel pumps, cooling systems, and automatic transmissions.

c. Used to measure the amount of pressure created in the cylinders of an engine.

d. Used to measure the amount of vacuum created by the engine or fuel pump.

? ?

Frame 18.

Answers to Questions 48 through 51:

48. d.

49. c.

50. a.

51. b.

The steel rule is used to measure small linear distances.

QUESTION 52.

? ?

? Circle the letter which identifies the correct answer below: ?

? The steel rule can be used to measure the ?

? a. circumference of the crankshaft. ?

? b. length of bolts and screws. ?

? c. diameter of a crankshaft. ?

? d. clearance between valves and rocker arms. ?

? ?

Frame 19.

Answer to Question 52: b. (length of bolts and screws).

The six-inch steel rule has four scales, two on each side.

The four scales on a steel rule are: 1/8", 1/16", 1/32", and 1/64".

Each inch on the 1/8 inch scale is divided into 8 parts.

Each inch on the 1/16 inch scale is divided into 16 parts.

Each inch on the 1/32 inch scale is divided into 32 parts.

Each inch on the 1/64 inch scale is divided into 64 parts.

The numerator is the top part of a fraction.

The denominator is the bottom part of a fraction.

When reading a measurement on a steel rule, count the number of full inches and write down that number. Count the number of marks past the last full inch and write that number as your numerator, then determine which scale you are using and write that number as your denominator.

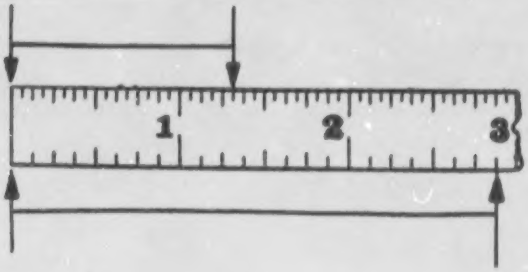
Frame 20.

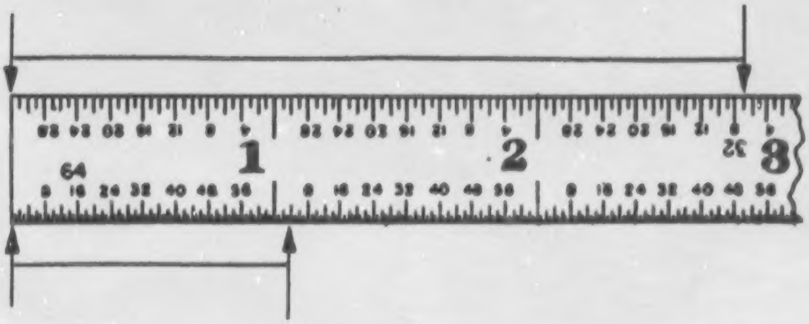
QUESTIONS 53 through 56.

? ?

? 53. The measurement shown on the 1/16 inch scale below is ________. ?

? 54. The measurement shown on the 1/8 inch scale below is ________. ?





? 55. The measurement shown on the 1/32 inch scale above is ________. ?

? 56. The measurement shown on the 1/64 inch scale above is ________. ?

? ?

Answers to Questions 53 through 56:

53. 1 5/16
54. 2 7/8
55. 2 25/32
56. 1 3/64

QUESTIONS 57 through 64.

? ?

Record the letter that identifies each measuring tool in the right column in the space provided beside its use in the left column.

_____ 57. Used to measure the amount of pressure created in the cylinders of an engine.

_____ 58. Used to measure the diameter and roundness of objects.

_____ 59. Used to measure end play, backlash, taper or wear, alignment, and out of roundness in thousandths of an inch.

_____ 60. Used to measure and adjust spark plug electrode gap.

_____ 61. Used to measure the clearance between two objects.

_____ 62. Used to measure small linear distances.

_____ 63. Used to measure the amount of pressure created in air brake systems, hydraulic brake systems, fuel systems, cooling systems, and automatic transmissions.

_____ 64. Used to measure the amount of vacuum created in the engine or fuel pump.

a. Spark plug gauge.
b. Pressure gauge.
c. Thickness gauge.
d. Vacuum gauge.
e. Micrometer.
f. Compression gauge.
g. Dial indicator.
h. Steel rule.

? ?

Frame 22.

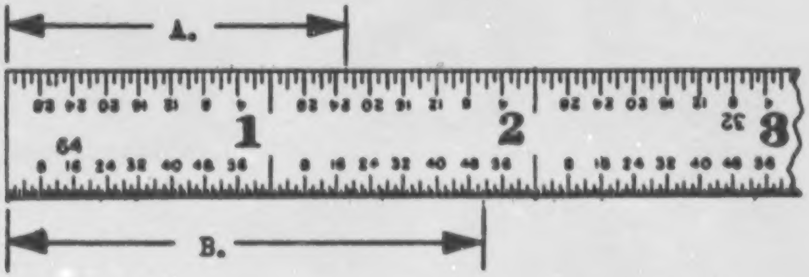
Answers for Questions 57 through 64.

57. f.   58. e.   59. g.   60. a.
61. c.   62. h.   63. b.   64. d.

QUESTIONS 65 through 68.

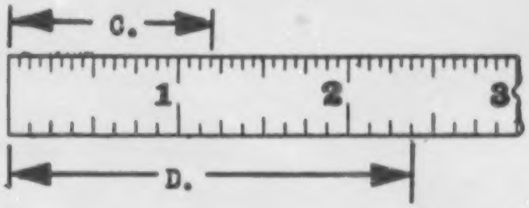
? ?

? 65. Record measurement "A". ______________ ?


A.
1
2
3
64
32
8 16 24 32 40 48 56
B.

? 66. Record measurement "B". ______________ ?

? 67. Record measurement "C". ______________ ?



? 68. Record measurement "D". ______________ ?

? ?

Answers for Questions 65 through 68:

65. 1 9/32 66. 1 51.64 67. 1 3/16 68. 2 3/8

QUESTIONS 69 through 73.

? ?

Record the letter that identifies each measuring tool in the space provided beside the name of the appropriate tool.

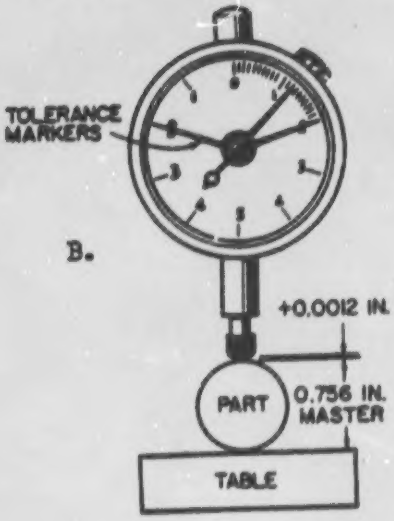
69. Micrometer _____

70. Thickness gauge _____

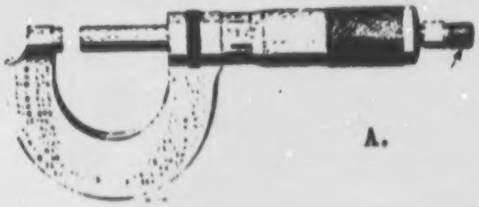
71. Spark plug gauge _____

72. Dial indicator _____

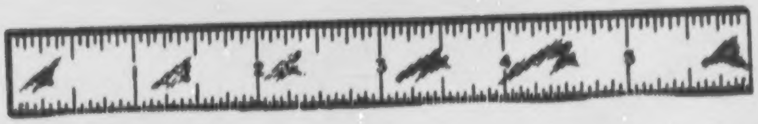
73. Steel rule _____


TOLERANCE MARKERS
+0.0012 IN.
PART
0.756 IN. MASTER
TABLE

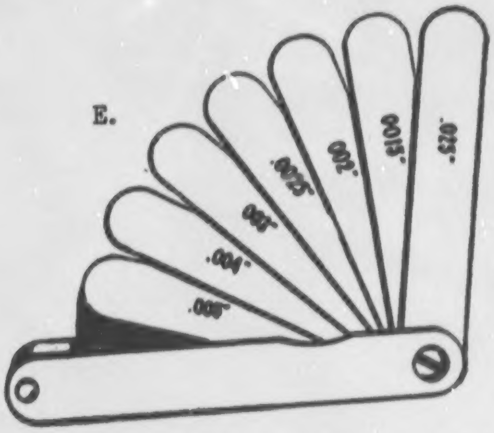
B.



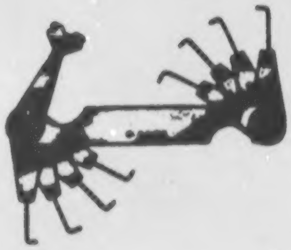
A.



C.


.003"
.004"
.005"
.0075"
.007"
.0015"
.020"

E.



D.

? ?

Frame 24.

Answers to Questions 69 through 73:

69. a.

70. e.

71. d.

72. b.

73. c.

THE END

8-9

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 15 Jan 75	INSTRUCTOR
COURSE NUMBER 3ABR47330	COURSE TITLE General Purpose Vehicle Repairman, Part 1
BLOCK NUMBER 11	BLOCK TITLE Engines

LESSON TITLE
Principles of Internal Combustion Engines and Engine Disassembly

LESSON DURATION

CLASSROOM/Laboratory D&D 4 Hrs/Perf 2 Hrs	XXXXXXXXX/Complementary 0 Hrs	TOTAL 6 Hrs

POI REFERENCE

PAGE NUMBER 5	PAGE DATE 2 January 1975	PARAGRAPH 1

STS/CTS REFERENCE

NUMBER STS 473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 60-2759 2. " 66-3299 3. " 60-2584 4. Mechanic's Common Hand Tools	None	None	1. 3ABR47330-SG-201 2. 3ABR47330-WB-202 3. 3ABR47330-WB-202A 4. Film: F C 23-55A

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references, identify basic facts, principles of operation, function and relationship of engine system and components with 70% accuracy.

Teaching Steps are Listed in Part 11

ATC FORM AUG 73 770

☆ GPO: 1973 779-806/80

INTRODUCTION

Approx 15 Min

1. Attention and Motivation: Gain students attention by asking questions about their experience with engines. Relate the importance of vehicle support to overall defense efforts.

2. Review: Briefly review the use of the technical order system as it relates to vehicle maintenance.

3. Overview & Tie-in: Participles, and classification, using applicable technical orders and commercial publications, and be able to answer written and/or oral questions with at least 70% accuracy.

BODY

Approx 5 Hrs 30 Min

PRESENTATION: Ref part 1 para a

1. Guide a discussion on terminology, the relationships involved, and how they apply to automotive engines

   a. Terminology

      (1) Mfg specs and their importance

      Show film, FLC 23-55A WHERE MILAGE BEGINS

      (2) Vacuum

      (3) Atmospheric pressure

      (4) Pressure differentials

   b. Four stroke cycle

   Summarize here
   60-2584, 4-stroke cycle trainer

      (1) Intake

      (2) Compression

      (3) Power

         (a) Heat

         (b) Pressure

      (4) Exhaust

- (a) Pressure
- (b) Valve overlap and its purpose

c. Operating theory and terms — Summarize here

- (1) T.D.C (Top Dead Center)
- (2) B.D.C. (Bottom Dead Center)
- (3) B.T.D.C. (Before Top Dead Center)
- (4) A.T.D.C. (After Top Dead Center)
- (5) Power overlap
- (6) Volumetric efficiency and how it is affected by speed and throttle opening
- (7) Compression ratios (volume relationships)
- (8) Compression pressures and how they vary with speed and throttle opening
- (9) Piston displacement
  - (a) Bore
  - (b) Stroke
- (10) Inertia (resistance to a change of speed or motion as related to the pistons and flywheel)
- (11) Torque (twisting force) — Summarize here

d. Two stroke cycle

- (1) Compression and power strokes only
- (2) Intake and exhaust between strokes

e. Engine classifications	61-2802 Chev Engine Cutaway 'V8'
(1) Block design	
(a) In-line	
(b) V-block	
(c) Horizontal opposed	
(2) Valve arrangement	
(a) I-head (both valves in head)	
(b) I-head (both valves in block)	
(c) F-head (exhaust valve in block, intake valve in head)	
(3) Cooling system	Summarize here
(a) Liquid	
(b) Air	
(4) Fuel	
(a) Gasoline	
(b) Diesel	
APPLICATION: Ref part 1 para a	Summarize here
1. Using tools, equipment, and applicable publications, the student will perform tasks assigned. All safety precautions will be observed and adhered to.	Use 3ABR47330-WB-202 Use 3ABR47330-WB-202A
a. Remove and/or disconnect the following engine components and accessories from engine trainer as directed	Trainer 60-2759, International engine assemblies Mechanic's Common handtools
(1) Electrical system units	
(2) Fuel system units	

(3) Exhaust system units

(4) Cooling system units

EVALUATION:

1. How are vacuum atmospheric pressure, and pressure differential related?

2. List in order the strokes of the four stroke cycle engine.

   ans: Intake, compression, power and exhaust.

3. How are engines classified?

   ans. Block design, valve arrangement, cooling system and fuel

4. How does the I-head differ from the L-head?

   ans: I-head has both valves in the head,

5. How do different speeds and throttle openings affect compression pressure?

   ans: As throttle opening increases, there is a larger volume of air/fuel mixture to be compressed into the same space, thus creating greater compression pressures.

6. How is volumetric efficiency related to compression pressure?

   ans: As volumetric efficiency goes down, there is a smaller amount of air/fuel mixture in the cylinder, therefore when it is compressed pressure in the cylinder, therefore when it is compressed in the cylinder will be lower.

7. How does a two stroke cycle engine differ from a four stroke cycle engine?

   ans: Every stroke of a two stroke cycle engine is either compression or power, while intake and exhaust are accomplished between strokes.

8. How is a power impulse transmitted to the flywheel?

ans: Through the piston, wrist pin, connecting rod, and crankshaft.

9. What is the purpose of the crankshaft?

ans: To change reciprocating motion to rotary motion.

10. How is valve movement related to piston position?

ans: The valves must open and close at the proper time in order that the air/fuel mixture is let into the cylinder on the intake stroke and so that both valves are closed on the compression and power stroke.

11. How is the correct relationship between valve position and piston position maintained?

ans: Timing gears or chains

12. Explain the operation of the valve mechanism?

ans: The camshaft changes rotary motion into reciprocating motion, which is then transferred to the valve through a mechanical linkage and opens the valve. The parts that transfer the motion are; the lifters, pushrods, and rocker arms. The valve is then closed by spring tension from the valve springs.

CONCLUSION

Approx 15 Min

SUMMARY AND REMOTIVATION:

1. Review the major areas of today's lesson to be sure the students have become familiar with the objectives and key points as stated on L/P covered sheet. Remotivate student by emphasizing why he needs to remember the objectives taught.

ASSIGNMENT AND CLOSURE:

1. Study Methods: Using SQ3R METHOD Study and answer questions at the end of the chapter or programmed text. Use study guide 3ABR47330-SG-202.

2. Wrap-up: This concludes the subject, but the information learned here will be applied as the student continues in the course. Review of this study guide and information is recommended throughout the course.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 15 Jan 75 Exam	INSTRUCTOR
COURSE NUMBER 3ABR47330	COURSE TITLE General Purpose Vehicle Repairman, Part 1
BLOCK NUMBER 11	BLOCK TITLE Engines

LESSON TITLE Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation, and Valve Adjustment

LESSON DURATION

CLASSROOM/Laboratory D&D 6 Hrs/Perf 12 Hrs	XXXXXXXX/Complementary 0 Hrs	TOTAL 18 Hrs

POI REFERENCE

PAGE NUMBER 6	PAGE DATE 2 January 1975	PARAGRAPH 2

STS/CTS REFERENCE

NUMBER STS 473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 60-2759 2. Measuring Devices + Special Tools 3. Spring Testers 4. Timing Light 5. Vacuum Pressure Gauge	1. Torque Wrench	None	1. 3ABR47330-SG-202 2. 3ABR47330-WB-202 3. 3ABR47330-WB-202A 4. Film TV 77-661

(Over) CRITERION OBJECTIVES AND TEACHING STEPS (Over)

a. Given an engine trainer and tools, practicing all safety precautions, disassemble an engine, following all the procedures outlined in the student workbook.

b. Given engine trainer and components, tools, equipment and workbook, practicing all safety precautions, inspect, repair, and/or service engine components IAW procedures and specifications in student workbook, with instructor guidance as required, on more difficult tasks.

c. Given engine trainer, tools and practicing all safety precautions, reassemble engine trainer following all the procedures outlined in student workbook.

d. Given engine trainer, workbook, tools and equipment, practicing automotive personnel and equipment shop safety, use visual, auditory, operational means and test equipment to check and adjust engine mechanical systems IAW procedures outlined in student workbook (Over

CRITERION OBJECTIVE AND TEACHING STEPS

Teaching Steps are Listed in Part 11

EQUIPMENT LOCATED IN LABORATORY

6. Engine Tachomometer
7. Compression Gauge
8. Rod Alignment Tester
9. Mechanic's Hand Tools, COMMON
10. Miscellaneous Engine Components

GRAPHIC AIDS & UNCLASSIFIED MATERIAL

5. Chart: CAFB 65-183

INTRODUCTION

Approx 30 Min

1. Attention & Motivation: Ask questions about air pollution devices, use personal experience of cooling and lubricating systems problems & relate to the student how this knowledge can help the repairman. Tell how these systems help engine operate smoother and last longer.

2. Review: Relate to previous lessons on engines & review questions at the end of Chapter 202 of the Student Study Guide.

3. Overview and TIE IN: At the end of today's lesson, students will describe the operation, inspection and repair of cooling, lubrication and crankcase ventilating systems and components.

BODY

Approx 5 Hrs

PRESENTATION/Application

1. Guide a discussion on the operating principles, inspection and repair of cooling, lubrication and crankcase ventilating systems and their components. Reference Part I Para III a&b

   a. Cooling systems

      (1) Purpose - dissipate excessive heat

      (2) Types

         (a) Liquid

         (b) Air

      (3) Components and servicing of a liquid cooling system

         (a) Pressure radiator cap

            Use special cap tester
            Use chart CAFB 65-183 "Pressure Radiator Cap"

            1 Seals system to prevent loss of coolant through overflow pipe under normal conditions

            2 Raises boiling point of coolant for higher temperature operation

            3 Check:

               a Proper pressure operation

b Operation of vacuum valve	Summarize here.
(b) Radiator	
1 Heat exchanger	
2 Check:	
a Flow test	
b Cold spots	
c Air suction	
d Pressure test	Use pressure cap tester
e Leaks - scale or water marks	
f Anti-freeze solution	
(c) Hoses	
1 Transfer coolant	
2 Check:	Show radiator hoses
a For cracks and leaks	
b For inside deterioration	
c For spongy feeling	Summarize here.
(d) Water jackets	
1 Check core hole plugs for leaks	
2 Exhaust gas leakage	
(e) Thermostat	Use thermostat tester and thermostats
1 Control operating temperature of engine	
2 Check for opening temperature	
(f) Water pump	Show water pump
1 Circulate coolant	

- 2 Check for:
    - a Leaks
    - b Bearing wear
    - c Operation by feeling surge in top radiator hose
- (g) Fan and belt — Summarize here.
    - 1 To draw air through radiator
    - 2 To drive water pump
    - 3 Check:
        - a Loose fan
        - b Bent fan blades
        - c Belt condition and proper tension
- (h) Coolant
    - 1 Check:
        - a Rust and scale
- (i) Accessories
    - 1 Temperature sending unit
    - 2 Temperature gauge
- (j) Clean cooling system
    - 1 Use cleaning compound
    - 2 Flush radiator and engine
    - 3 Back flush if necessary

(4) Components of air cooling systems — Summarize here.

- (a) Head and barrel design (finned)
- (b) Air deflectors, shrouds or baffles

(c) Fans

(d) Oil cooler

b. Lubricating system

Summarize here.

(1) Purpose

Use chart CAFB 65-182 "Lubrication system, In-line and V-type engines"

(a) Reduce friction

(b) Assist in cooling

(c) Clean engine parts

(d) Seal piston rings and cylinder walls to prevent blow-by

(e) Absorbs shock

(2) Engine oil

(a) Classified according to its resistance to flow (viscosity)

(b) Graded by a series of SAE numbers (SAE10W, 20 20W, etc)

(c) Service rating (SE, SD, SC, SB, SA: CD, CC, CB, and CA)

(d) Check engine oil level

(3) Types of lubricating systems

(a) Splash (obsolete)

(b) Splash and force feed

(c) Force

(d) Full force feed or full pressure

(4) Components

Summarize here

(a) Oil pan

1 Oil reservoir

2 Check for:

a Dents

b Leaks

c Sludge accumulation

(b) Oil strainer (pick-up)

1 Hinged to oil pump

2 Floats on surface of oil

3 Check:

a Freedom of movement

b Intake screen

(c) Oil pump

1 Provides oil under pressure to all moving parts

Use chart CAFB 63-241
"Oil pumps"

2 Types of pumps

Use oil pumps

a Gear

b Rotor

c Vane

3 Pressure relief valve

a Controls maximum pressure

4 Check pump for:

a Gear backlash

b Shaft clearance

c Gear and housing clearance

d Cracks, etc

(d) Oil galleries

1 Drilled passages in block

2 Clean with compressed air

(e) Oil filter

1 Types of oil filters

a Full flow	Use oil filters
b Partial flow	
2 Removes dirt	
3 Replace oil filter as necessary	
(f) Sending unit and gauge	Summarize here.
c. Crankcase ventilation	
(1) Purpose	
(a) Reduce air pollution	
(b) Reduce oil dilution and engine sludge formation	
1 Removes gasoline vapors	
2 Removes water vapors	
(2) Types	
(a) Draft tube (non-positive)	Use chart CAFB 66-73 "Non-positive crankcase ventilation"
1 On most cars built prior to 1963	
2 Not very effective at speeds less than 20 mph	
3 Air velocity causes vapors to be drawn out of crankcase	
(b) Positive crankcase ventilation (PCV)	Use chart CAFB 59-3332 "Positive crankcase ventilation"
1 Open system	
a Same basic operating principle as road draft tube	
b Use manifold vacuum for source of draft	
c Requires PCV valve	
d Vapors are mixed with air/fuel mixture and burned	

2 Closed system

a More effective

b All outlets sealed

c Vapors enter air cleaner

d Mixed with fresh air entering carburetor

e Rerouted (via intake manifold) to combustion chambers to be reburned — Summarize here.

d. Valve reconditioning Ref. Part I Para. 3c

(1) Purpose

(a) To help maintain proper compression — Use valve reconditioning equipment

(2) Use of refacing equipment

(a) Check abrasive wheel for cracks — Use valve refacer instructions

(b) Check coolant and oil levels

(c) Dress abrasive wheel with a diamond dresser

(d) Set workhead to desired angle

(e) Position valve in workhead

(f) Grind valves to specifications

(g) Dress recessed abrasive wheel

(h) Grind valve stem end and rocker arm — Summarize here.

(3) Valves — Use valves & valve springs

(a) Inspection

1 Burned

2 Warped

3 Margin width

        (b) Cleaning

        (c) Reconditioning

            1 Angle of face

            2 Interference angle

    (4) Valve seat reconditioning

        (a) Inspection

            1 Cracks

            2 Pits

        (b) Cleaning — Use drill and wire brush

        (c) Reconditioning

            1 Seat angle

            2 Seat width

            3 Narrowing seat

    (5) Demonstrate the use of valve and valve seat reconditioning equipment, stressing safe use of the equipment. — Common hand tools, spring testers, and International cylinder heads

Summarize here.

EVALUATION:

1. What is a thermostat tested for?

   Ans: Opening temperature.

2. Why should a radiator be flow tested?

   Ans: To see if it is clogged.

3. How is a cooling system checked for exhaust gas leakage?

   Ans: Operate engine with fan belt removed, observe coolant in radiator.

4. Why is lubrication necessary?

   Ans: Reduce friction, seals, cools and cleans.

5. What does the term service rating mean?

   Ans: Rating of oil for the type of service it is best suited.

6. What are the two most common types of oil pumps?

   Ans: Gear and rotor.

7. What could cause low oil pressure?

   Ans: Bad rod, main, or cam bearing, or a defective relief valve spring.

8. Why is crankcase ventilation necessary?

   Ans; To reduce air pollution and to remove harmful vapors and condensation from engine lubrication oils.

9. What determines the amount a valve can be ground?

   Ans: The margin.

10. How is a valve seat narrowed?

    Ans: By grinding the top or inside edges.

11. Is it always necessary to dress a valve grinding stone before use? Why?

    Ans: Yes. To achieve a proper grinding result.

12. What are tow things to check on a valve grinder before using it?

    Ans: Coolant and oil level.

CONCLUSION

Approx 30 Min

SUMMARY & REMOTIVATION:

1. Review key points of cooling, lubrication, crankcase vehtilating systems and valve grinding and key points as stated on L/P cover sheet.
2. Remotivate students by emphasizing need to remember objectives taught.

ASSIGNMENT AND CLOSURE:

1. SSG Chapter 203 and today's notes.
2. Study methods: Using the SQ3R study methods, study and answer the questions at the end of the chapter or programmed text.
3. Wrap-up: This will conclude this subject. The information learned here will be applied as the student continues in the course. Review of this study guide and information is recommended throughout the course.

LESSON PLAN (Part I, General)

APPROVAL OFFICE AND DATE TWSTI 15 Jan 75	INSTRUCTOR
COURSE NUMBER 3ABR47330	COURSE TITLE General Purpose Vehicle Repairman, Part 1
BLOCK NUMBER 11	BLOCK TITLE Engines

LESSON TITLE Principles, Inspection and Repair of Cooling, Lubrication and Crankcase Ventilating Systems, and the Use of Valve Reconditioning Equip.

LESSON DURATION

CLASSROOM /Laboratory D&D 3 Hrs/Perf 3 Hrs	~~XXXXXXX~~/Complementary 0 Hrs	TOTAL 6 Hrs

POI REFERENCE

PAGE NUMBER 7	PAGE DATE 2 January 1975	PARAGRAPH 3

STS/CTS REFERENCE

NUMBER STS 473X0	DATE 3 September 1974

SUPERVISOR APPROVAL

SIGNATURE	DATE	SIGNATURE	DATE

PRECLASS PREPARATION

EQUIPMENT LOCATED IN LABORATORY	EQUIPMENT FROM SUPPLY	CLASSIFIED MATERIAL	GRAPHIC AIDS AND UNCLASSIFIED MATERIAL
1. Trainer: 60-2759 2. Measuring Tools & Devices 3. Spring Testers 4. Valve reconditioning Equip. 5. Thermostat testers (Over)	None	None	1. 3ABR47330-SG-203 2. Valve Refacer Instructions 3. Chart: CAFB 65-183 4. " " 65-182 (Over)

CRITERION OBJECTIVES AND TEACHING STEPS

a. Without references identify basic facts and terms relative to the principles, function and relationship of cooling, lubricating and crankcase ventilating systems, with 70% accuracy.

b. Given engine trainer, tools, equipment and practicing personnel and equipment shop safety, repair or service lubricating, cooling and crankcase ventilating systems following procedures outlined in student study guide.

c. Given tools, equipment, engine trainer, practice personnel and equipment shop safety, repair or service valves and mechanisms IAW manufacturer's manual. Instructor assistance required on more difficult tasks.

Teaching Steps are Listed in Part 11

ATC FORM AUG 72 770

☆ GPO: 1972 779-396/33

EQUIPMENT LOCATED IN LABORATORY

6. Pressure Cap Testers
7. Mechanic's Common Handtools
8. Back Flushing Equipment
9. Special Tools
10. Miscellaneous Engine Components

GRAPHIC AIDS AND UNCLASSIFIED MATERIAL

5. Chart: CAFB 63-241
6. " " 66-73
7. " " 59-3332

INTRODUCTION

Approx 30 Min

1. Attention & Motivation: Ask questions about air pollution devices, use personal experience of co-ling and lubricating systems problems & relate to the student how this knowledge can help the repairman. Tell how these systems help engine operate smoother and last longer.

2. Review: Relate to previous lessons on engines & review questions at the end of Chapter 202 of the Student Study Guide.

3. Overview and TIE-IN: At the end of today's lesson, students will describe the operation, inspection and repair of cooling, lubrication and crankcase ventilating systems and components.

BODY

Approx 5 Hrs

PRESENTATION/APPLICATION

1. Guide a discussion on the operating principles, inspection and repair of cooling, lubrication and crankcase ventilating systems and their components. Ref part 1 para a & b

    a. Cooling systems

        (1) Purpose - dissipate excessive heat

        (2) Types

            (a) Liquid

            (b) Air

        (3) Components and servicing of a liquid cooling system

            (a) Pressure radiator cap

Use special cap tester
Use chart CAFB 65-183
"Pressure Radiator Cap"

                1 Seals system to prevent loss of coolant through overflow pipe under normal conditions

                2 Raises boiling point of coolant for higher temperature operation

                3 Check:

                    a Proper pressure operation

b Operation of vacuum valve	Summarize here
(b) Radiator	
1 Heat exchanger	
2 Check:	
a Flow test	
b Cold spots	
c Air suction	
d Pressure test	Use pressure cap tester
e Leaks - scale or water marks	
f Anti-freeze solution	
(c) Hoses	
1 Transfer coolant	
2 Check:	Show radiator hoses
a For cracks and leaks	
b For inside deterioration	
c For spongy feeling	Summarize here
(d) Water jackets	
1 Check core hole plugs for leaks	
2 Exhaust gas leakage	
(e) Thermostat	
1 Control operating temperature of engine	Use thermostat tester and thermstats
2 Check for opening temperature	
(f) Water pump	Show water pump
1 Circulate coolant	

- 2 Check for:
  - a Leaks
  - b Bearing wear
  - c Operation by feeling surge in top radiator hose
- (g) Fan and belt — Summarize here
  - 1 To draw air through radiator
  - 2 To drive water pump
  - 3 Check:
    - a Loose fan
    - b Bent fan blades
    - c Belt condition and proper tension
- (h) Coolant
  - 1 Check:
    - a Rust and scale
- (i) Accessories
  - 1 Temperature sending unit
  - 2 Temperature gauge
- (j) Clean cooling system
  - 1 Use cleaning compound
  - 2 Flush radiator and engine
  - 3 Back flush if necessary

(4) Components of air cooling systems — Summarize here

- (a) Head and barrel design (finned)
- (b) Air deflectors, shrouds or baffles
- (c) Fans

(d) Oil cooler

b. Lubricating system — Summarize here

(1) Purpose — Use chart CAFB 65-182 "Lubrication system, IN-LINE and V-type engines"

(a) Reduce friction

(b) Assist in cooling

(c) Clean engine parts

(d) Seal piston rings and cylinder walls to prevent blow-by

(e) Absorbs shock

(2) Engine oil

(a) Classified according to its resistance to flow (viscosity)

(b) Graded by a series of SAE numbers (SAE10W, 20 20W, etc)

(c) Service rating (SE, SD, SC, SB, SA: CD, CC, CB, and CA)

(d) Check engine oil level

(3) Types of lubricating systems

(a) Splash (obsolete)

(b) Splash and force feed

(c) Force

(d) Full force feed or full pressure

(4) Components — Summarize here

(a) Oil pan

1 Oil reservoir

2 Check for:

a Dents

b Leaks

        - c Sludge accumulation

- (b) Oil strainer (pick-up)
    - 1 Hinged to oil pump
    - 2 Floats on surface of oil
    - 3 Check:
        - a Freedom of movement
        - b Intake screen
- (c) Oil pump
    - 1 Provides oil under pressure to all moving parts — Use chart CAFB 63-241 "Oil pumps"
    - 2 Types of pumps — Use oil pumps
        - a Gear
        - b Rotor
        - c Vane
    - 3 Pressure relief valve
        - a Controls maximum pressure
    - 4 Check pump for:
        - a Gear backlash
        - b Shaft clearance
        - c Gear and housing clearance
        - d Cracks, etc
- (d) Oil galleries
    - 1 Drilled passages in block
    - 2 Clean with compressed air
- (e) Oil filter
    - 1 Types of oil filters

a Full flow	Use oil filters
b Partial flow	
2 Removes dirt	
3 Replace oil filter as necessary	
(f) Sending unit and gauge	Summarize here
c. Crankcase ventilation	
(1) Purpose	
(a) Reduce air pollution	
(b) Reduce oil dilution and engine sludge formation	
1 Removes gasoline vapors	
2 Remove water vapors	
(2) Types	
(a) Draft tube (non-positive)	Use chart CAFB 66-73 "Non-positive crankcase ventilation"
1 On most cars built prior to 1963	
2 Not very effective at speeds less than 20 mph	
3 Air velocity causes vapors to be drawn out of crankcase	
(b) Positive crankcase ventilation (PCV)	Use chart CAFB 59-3332 "Positive crankcase Ventilation:
1 Open system	
a Same basic operating principles as road draft tube	
b Use manifold vacuum for source of draft	
c Requires PCV valve	
d Vapors are mixed with air/fuel mixture and burned	

2 Closed system

  a More effective

  b All outlets sealed

  c Vapors enter air cleaners

  d Mixed with fresh air entering carburetor

  e Rerouted (via intake manifold) to combustion chambers to be reburned

Summarize here

d. Valve reconditioning Ref part 1 para c

(1) Purpose

  (a) To help maintain proper compression

Use valve reconditioning equipment

(2) Use of refacing equipment

  (a) Check abrasive wheel for cracks

Use valve refacer instructions

  (b) Check coolant and oil levels

  (c) Dress abrasive wheel with a diamond dresser

  (d) Set workhead to desired angle

  (e) Position valve in workhead

  (f) Grind valves to specifications

  (g) Dress recessed abrasive wheel

  (h) Grind valve stem end and rocker arm

Summarize here

(3) Valves

Use valves & valve springs

  (a) Inspection

    1 Burned

    2 Warped

    3 Margin width

        (b) Cleaning

        (c) Reconditioning

            1 Angle of face

            2 Interference angle

    (4) Valve seat reconditioning

        (a) Inspection

            1 Cracks

            2 Pits

        (b) Cleaning — Use drill and wire brush

        (c) Reconditioning

            1 Seat angle

            2 Seat width

            3 Narrowing seat

    (5) Demonstrate the use of valve and valve seat reconditioning equipment, stressing safe use of the equipment — Common handtools, spring testers, and International cylinder heads

    Summarize here

EVALUATION:

1. What is a thermostat tested for?

    a. Opening temperature

2. Why should a radiator be flow tested?

    a. To see if it is clogged

3. How is a cooling system checked for exhaust gas leakage?

    a. Operate engine with fan belt removed, observe coolant in radiator

4. Why is lubrication necessary?

    a. Reduce friction, seals, cools and cleans

5. What does the term service rating mean?

    a. Rating of oil for the type of service it is best suited

6. What are the two most common types of oil pumps?

   a. Gear and rotor

7. What could cause low oil pressure?

   a. Bad rod, main, or cam bearing, or a defective relief valve spring

8. Why is crankcase ventilation necessary?

   a. To reduce air pollution and to remove harmful vapors and condensation from engine lubrication oils

9. What determines the amount a valve can be ground?

   a. The margin

10. How is a valve seat narrowed?

    a. By grinding the top or inside edges

11. Is it always necessary to dress a valve grinding stone before use? Why?

    a. Yes. To achieve a proper grinding result

12. What are two things to check on a valve grinder before using it?

    a. Coolant and oil level

CONCLUSION

Approx 30 Min

SUMMARY AND REMOTIVATION:

1. Review key points of cooling, lubrication, crankcase ventilating systems and valve grinding and key points as stated on L/P cover sheet.

2. Remotivate students by emphasizing need to remember objectives taught.

ASSIGNMENT AND CLOSURE:

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PREPARE THE MAN

STUDY GUIDE 3ABR47330-SG-200

8-9

Technical Training

General Purpose Vehicle ~~Repairman~~ Mechanic

BLOCK II
ENGINES

6 December 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes SG 3ABR47330-201 Through 207, 13 December 1968.
OPR: TDWS
DISTRIBUTION: X
TDWS - 550; TTOC - 2

Designed For ATC Course Use

DO NOT USE ON THE JOB

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CONTENTS

UNIT	TITLE	PAGE
201	Principles of Internal Combustion Engines, and Engine Disassembly	1 through 12
202	Engine Disassembly, Engine Components Inspection and Parts Servicing, Engine Reassembly, Operation and Valve Adjustment	13 through 30
203	Principles, Inspection and Repair of Cooling, Lubrication, and Crankcase Ventilating Systems, and the use of Valve Reconditioning Equipment	31 through 47
206	Gasoline Engine Fuel System Units	49 through 56
207	Construction and Operating Principles of Carburetors and Governors	57 through 86
208	Service, Repair and Adjustment of Carburetors and Governors	87 through 97

AUTOMOTIVE TERMINOLOGY, DEFINITION AND PURPOSE OF ENGINE COMPONENTS

Listing on the following pages include the terminology, definition and purpose of engine components. An understanding of this subject material will aid you throughout the instructional period on engines.

Automotive Terminology

ATDC - After top dead center.

Atmospheric pressure - At sea level and an average temperature, air weighs about 0.08 of a pound per cubic foot. The weight of air that surrounds the Earth pushes down on us with a pressure of 14.7 pounds per square inch at sea level, this is atmospheric pressure.

BDC - Bottom dead center, when the piston is at the bottom of its stroke.

Bore - The diameter of a cylinder.

BTDC - Before top dead center.

Compression Pressure - Amount of pressure developed in a cylinder on the compression stroke, measured in pounds per square inch or psi.

Compression Ratio - The ratio of the volume of a cylinder when the piston is at BDC to the volume when the piston is at TDC.

Cycle - The completion of a series of events.

Friction - Resistance to motion.

Heat - Rapid motion of atoms.

Inertia - Resistance to a change of speed or direction. For example; if an automobile is sitting still on flat ground, it won't move unless some force is applied to it. Also, if an automobile was rolling at a given speed and in a given direction, it would continue to travel at that speed and in that direction forever unless friction, or some other outside force stopped it or changed its direction.

Piston Displacement - The volume of air a piston displaces as it moves from BDC to TDC.

Reciprocating Motion - Motion of a piston in a cylinder.

Specifications - Manufacturers exact measurements.

Stroke - The distance a piston travels from TDC to BDC.

Torque - Torque is a twisting force. This is the same type of force used to tighten a nut or bolt.

TDC - Top dead center, when the piston is at the top of its stroke.

Vacuum - When air is removed from a given space then air pressure within that space is less than atmospheric pressure. This low pressure area is then called a vacuum.

Viscosity - The tendency of oil to resist flowing.

Volumetric Efficiency - How efficiently an engine fills up its cylinders with air and fuel, and how efficiently it gets rid of the exhaust gases after combustion. For example; if the cylinder of a one cylinder engine could hold a cubic foot of air, but for some reason it would only fill up half a cubic foot of air, then it would only be 50% efficient.

Engine Parts and Their Purposes

Camshaft - Syncronizes valve opening with piston movement, drives the distributor and/or the oil pump and fuel pump. This shaft is supported in one piece bushing type bearings that are inserted into the block.

Connecting Rod - Transmits the force received by the piston to the crankshaft; the lower end is split to permit clamping around the crankshaft.

Connecting Rod Bearing - These pieces allow the rod to rotate around the crankshaft journal. They are of the two piece insert type.

Crankcase - This is usually the lower half of the engine block. The crankcase provides a solid support for the crank shaft and is removable on some engines.

Crankshaft - Changes the reciprocating motion of the pistons into more useful rotary motion.

Cylinder Block - The block contains the cylinders and the passages for the oil and coolant.

Cylinder Head - The cylinder head closes off the top of the cylinder, contains the combustion chamber, the passages for oil and coolant as well as the valve guides and the valve seats.

Heat Control Valve - Aids fuel vaporization during engine warmup by circulating warm gasses around the base of the carburetor.

Main Bearings - These pieces give the crankshaft a smooth surface to turn in. They are of the two piece insert type and one or more of them is used to control crankshaft end-play; it is known as the main thrust bearing.

Manifolds, Intake and Exhaust - These parts are actually fuel passages into and out of the combustion chamber. The exhaust manifold contains a valve known as the heat control valve or the heat riser.

Pistons - Receives the force of combustion and transmits it to the crankshaft through the connecting rod.

Piston Pin - Connects the piston to the connecting rod.

Piston Rings - Maintain a gas tight seal between the piston and the cylinder wall, assists in cooling the piston, and controls cylinder wall lubrication.

Pushrod - Transfers motion from the valve lifter to the rocker arm.

Rocker Arm - Picks up motion from the push rod, rotates a few degrees and unseats the valve.

Rocker Arm Shaft - Provides a pivot point for rocker arm.

Timing Gears or Chain - Connects the camshaft and the crankshaft together so the valves and pistons are timed correctly to each other.

Valve - Intake valve permits fuel mixture to enter cylinder, usually made of nickle chromium alloy. Exhaust valve allows burned gasses to escape and is usually made of a silichrome alloy and may contain sodium.

Valve Lifter (tappet or cam followers) - These may be either solid or hydraulic. They transmit motion from the camshaft to the push rod.

Valve Springs (reseats valves) - Pushes rocker arm back up in readiness for the next valve operation.

Vibration Damper - Also called the harmonic balancer, it reduces torsional vibrations that occur in the crankshaft.

Components of Vehicle Cooling Systems

Liquid Cooling Systems

Accessories - Temperature sending and receiving units, indicate the temperature of the coolant or warn operator of an overheat condition.

Fan and Belt - Circulates air through the radiator.

Hoses - Transmit coolant from the engine to the radiator and back.

Pressure Radiator Cap - he cap seals the coolant into the system and raises the boiling point of the coolant for higher temperature operation.

Radiator - Acts as a heat exchanger to remove excess heat.

Thermostat - Controls the temperature of the coolant.

Water Jackets - These are the passages in the block where coolant circulates.

Water Pump - Circulates the coolant throughout the engine.

Air Cooling Systems

Air Deflectors, Shrouds, and Baffles - These parts are vanes or fins that are designed to direct the flow of air to the hot engine parts.

Fans - The fan circulates air over the entire engine.

Head and Barrel Design (finned) - This design allows for maximum circulation of air around each individual cylinder.

Oil Cooler - A small oil radiator to assist in cooling the motor oil.

Components of Lubrication Systems

Oil filter - The oil filter removes dirt and impurities from the oil.

Oil Galleries - Drilled passages in the block to transfer oil through the system.

Oil Pan - The engines oil resevoir.

Oil Pump (positive displacement) - The pump circulates oil throughout the system and maintains oil pressure.

Oil Strainer - The oil pickup, its hinged and flats on the surface of the oil.

Sending Unit and Gauge - Indicates the amount of oil pressure or warns the operator when the oil pressure is too low.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-201

282

PRINCIPLES OF INTERNAL COMBUSTION ENGINES, AND ENGINE DISASSEMBLY

OBJECTIVES

After completing this study guide and your classroom instruction, you will be able to explain the principles of an internal combustion engine and relate the functions of its various parts to engine operation.

INTRODUCTION

Today's automotive engine is a precision piece of equipment; and it requires a great amount of skill and knowledge to perform the maintenance necessary to keep these engines operating properly.

INFORMATION

BASIC OPERATION

To begin with, two tin cans will be used as a simplified example of an automotive engine. This example will then be expanded until a complete automotive engine is described.

When choosing these cans, make sure one of them is slightly smaller than the other. The first step will be to cut one end out of each can, and then fill the larger can with a vaporized mixture of air and gasoline.

The next step will be to put the smaller can, closed end first, into the larger can and push it as far into the large can as possible. This second step will squeeze or compress the air-fuel mixture trapped between the two cans. At this point, if the air-fuel mixture could be set on fire, it would produce a large amount of heat, cause the air to expand rapidly, and thereby create sufficient pressure to drive the small can out of the larger one with a powerful thrust. Finally, the burned gasses would have to be removed from the large can and then the process or cycle could be started over again for another power stroke. In its simplest form, this is what happens inside a gasoline engine. Fuel, air, and fire were used to produce the power, and the two cans trapped the power so that it could have been used for a purpose. From this point on, the large can will be referred to as a cylinder, and the small one as a piston.

The next step is to create a series of mechanical links that will accomplish two things; first, it is necessary to change the up and down, or reciprocating, motion of the piston into a more useful rotary motion, second, the power produced in the combustion chamber must be transferred to the rear of the engine in order to

301

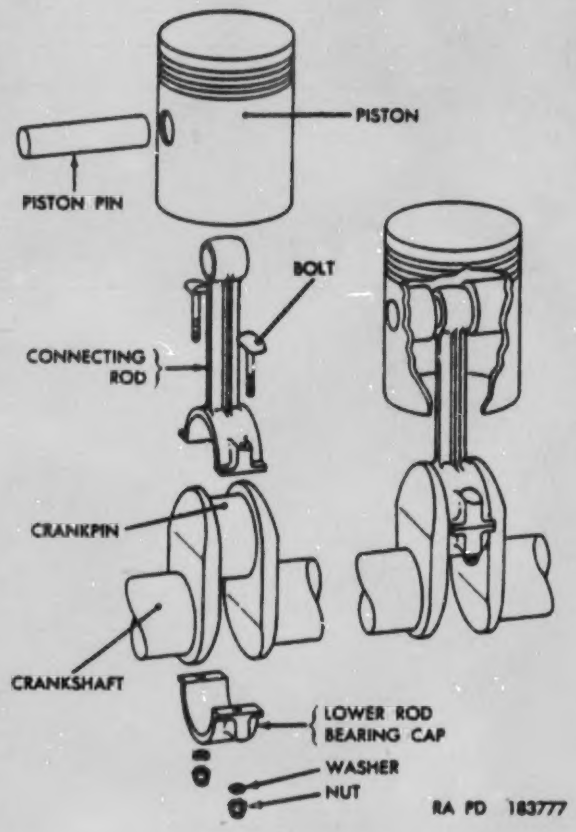

PISTON
PISTON PIN
BOLT
CONNECTING ROD
CRANKPIN
CRANKSHAFT
LOWER ROD BEARING CAP
WASHER
NUT
RA PD 183777

Figure 1. Piston, Connecting Rod, and Piston Pin.

operate the transmission and drive line. Refer to figure 1 and study the relationship of the parts shown. The parts pictured in figure 1 are the mechanical links used to transfer the power produced in the combustion chamber to the rear of the engine. The piston pin may also be referred to as a wrist pin, and the crankpin is usually called a crankshaft journal. Figure 2 illustrates three different mounting arrangements for piston pins.

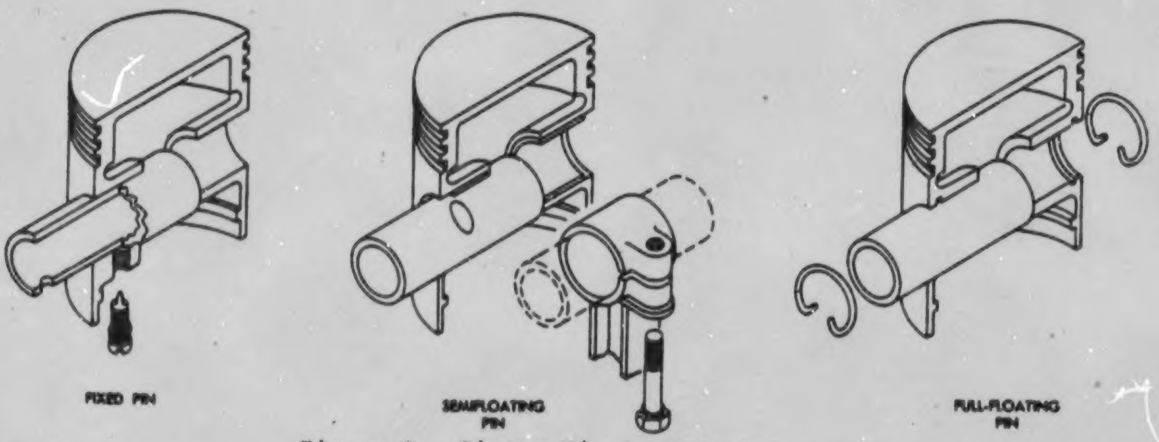

FIXED PIN
SEMIFLOATING PIN
FULL-FLOATING PIN

Figure 2. Piston Pin Arrangements.

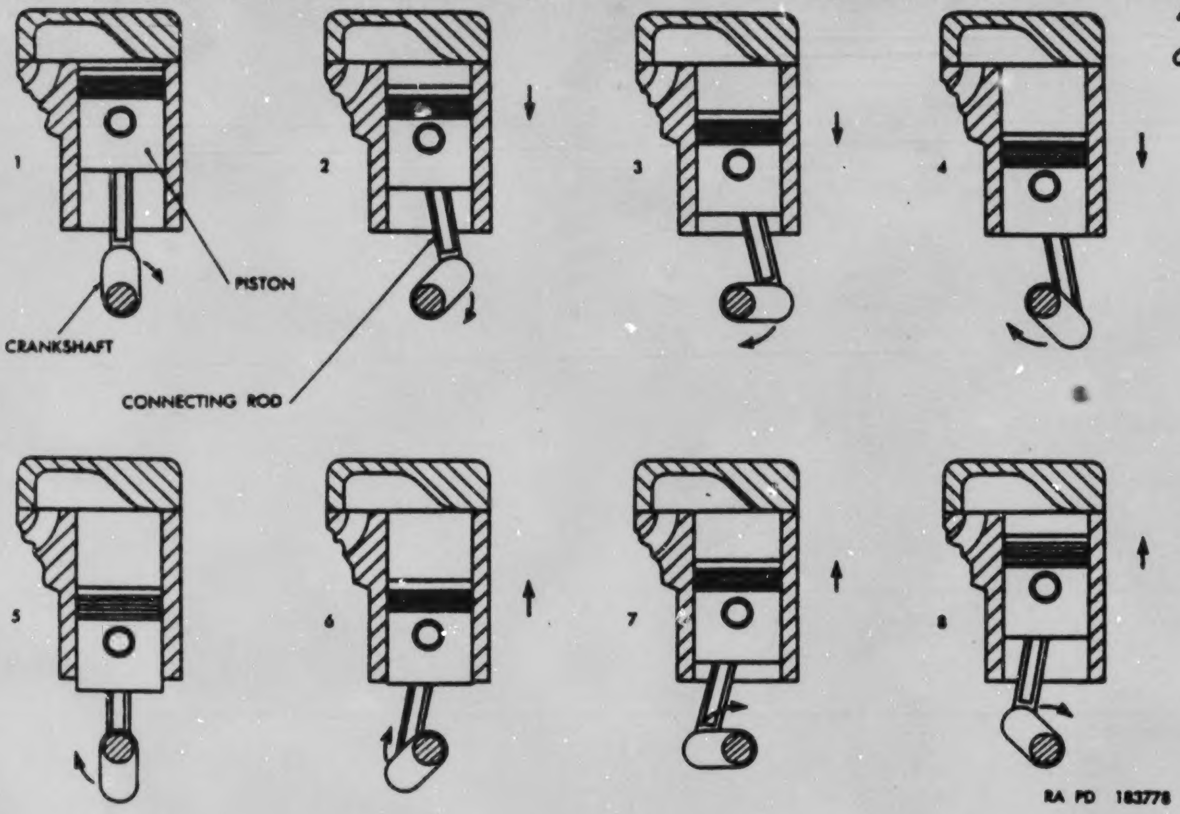


Figure 3. Relationship of Piston, Connecting Rod, and Crank on Crankshaft as Crankshaft Turns One Revolution.

Refer next to figure 3 and take note of the relationship between the connecting rod and the crankshaft. The connecting rod is mounted off center from the centerline of the crankshaft. By mounting the connecting rod in this manner, the crankshaft changes the reciprocating motion of the piston into rotary motion. The crankshaft supports hold a two-piece bearing insert. The insert is called a main bearing. One of the inserts has a flange on it that controls the back and forth movement of the crankshaft or, crankshaft end-play. This bearing is referred to as the main thrust bearing. A two-piece bearing insert is also used inside the connecting rod where it clamps onto the crankshaft. These bearings provide a smooth sliding surface so that the crankshaft and connecting rod can turn freely. The connecting rod bearing is pictured in figure 4. Also illustrated in figure 4 are piston rings. The rings have been added to the top of the piston to seal in the air-fuel mixture while it is being compressed. They also seal in the power of combustion, keep lubricating oils out of the top of the cylinder, or more accurately, the combustion chamber, and help transfer heat from the head of the piston. All the parts previously discussed and most of those that follow, go inside a block of cast metal. The upper part of this casting is referred to as the cylinder block, while the lower section that houses the crankshaft is called the crankcase. Finally, the top of the cylinder has been made so that it is removeable, and it is termed the cylinder head. It also contains the combustion chamber.

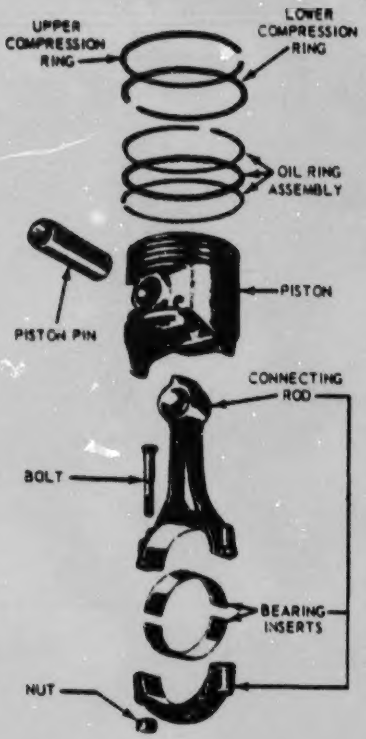


Figure 4. Piston, Piston Rings, Connecting Rod, and Connecting Rod Bearings.

In order for an engine to run continuously, some method of getting an air-fuel mixture into the cylinder, and getting the burned gases out is needed. This is the function of the valves and valve operating mechanism. Two valves are used for each cylinder. One is called an intake valve and it admits the air fuel mixture into the cylinder; the other is called an exhaust valve and it allows the burned gasses to escape after combustion has taken place. Both valves must be tightly closed when the air fuel mixture is compressed, and during combustion, so that power is sealed into the cylinder. The valves are held closed by stiff coil springs referred to as valve springs. The valve itself sits in a circular opening called a valve seat. Figure 5 illustrates a typical automotive valve and the names of the different areas of the valve. In order to open the valves at the correct time a camshaft is used. This shaft has small lobes on it and as it rotates, the lobes lift the valve open through a series of mechanical linkages. Figure 6 illustrates the valve lifter or tappet (which may be either the solid or hydraulic type). On some engines these linkages may include push rods and rocker arms, figure 7. The operation of the valves must be synchronized with piston movement so that, (1) the air-fuel mixture is let into the cylinder at the right time, (2) the valves remain closed for compression and power, and (3) the exhaust gasses are let out of the cylinder after the power stroke. This is accomplished by putting gears on the camshaft and crankshaft. These gears are either meshed directly or through a timing chain. Each timing gear has a reference mark

286

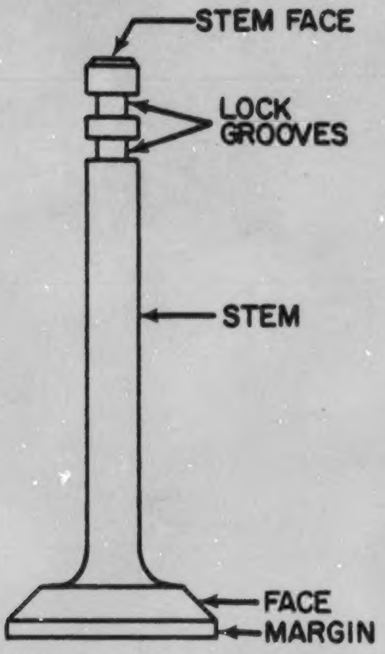


Figure 5. Valve Nomenclature.

on it that must be aligned when the shafts are installed. The camshaft gear is twice as large as the crankshaft gear. This 2 to 1 gear ratio enables the camshaft to turn at half the speed of the crankshaft so that the valves will remain closed during the compression and power strokes.

The engine that has been built up from the two tin cans in the beginning example is illustrated in figure 6. There is however, one more thing to consider. What actually makes the air-fuel mixture move into the cylinder, and what makes the exhaust gasses move out? A simple example will answer both these questions. When a toy balloon is blown up, a high pressure area is created inside the balloon. That is, the air pressure inside the balloon is higher than air pressure outside the balloon. Now, if the balloon is released, the high pressure area inside the balloon forces itself out into the lower pressure outside the balloon. This difference in pressure is called a pressure differential, and remember, the high pressure area moves to the lower pressure area. In an engine this same principle works as follows: as a piston goes down in the cylinder it makes room for more air to come into the cylinder, or in other words, it creates a low pressure area or partial vacuum. Normal air or atmospheric pressure is 14.7 pounds per square inch (PSI). This pressure is higher than it is in the cylinder, therefore, air rushes into the cylinder through the carburetor, and intake manifold. At this point the valves close and the piston moves up and compresses the air and fuel, then with the piston near the top of the cylinder, the ignition system sets the mixture on fire. The heat of combustion

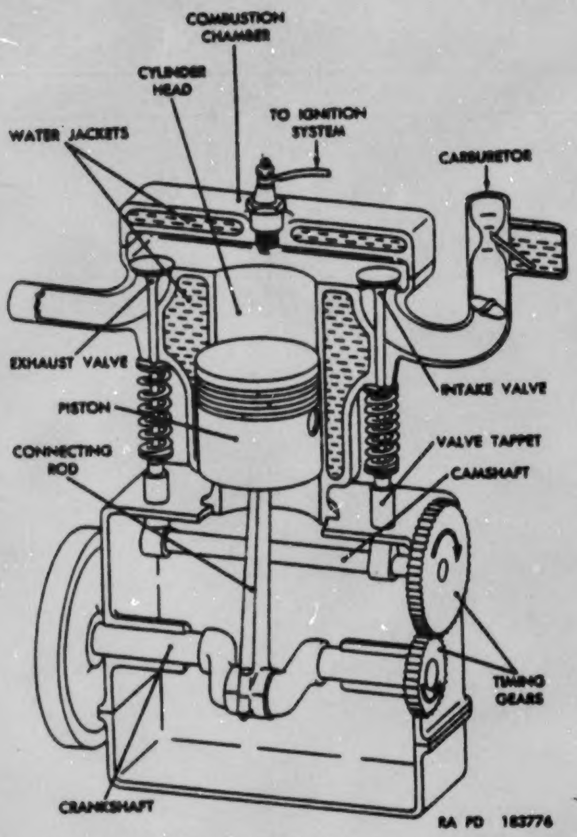

COMBUSTION CHAMBER
CYLINDER HEAD
TO IGNITION SYSTEM
WATER JACKETS
CARBURETOR
EXHAUST VALVE
INTAKE VALVE
PISTON
CONNECTING ROD
VALVE TAPPET
CAMSHAFT
TIMING GEARS
CRANKSHAFT
RA PD 183776

Figure 6. Single-Cylinder, 4-Stroke Cycle, Internal Combustion, Gasoline Engine.

causes the gasses in the cylinder to expand and create a very high pressure that drives the piston down. Just before the piston reaches the bottom of its stroke, the exhaust valve opens and the high pressure gasses force their way out through the exhaust manifold and exhaust system, and as the piston comes up on the exhaust stroke it helps to clear out the cylinder by pushing the burned gasses out.

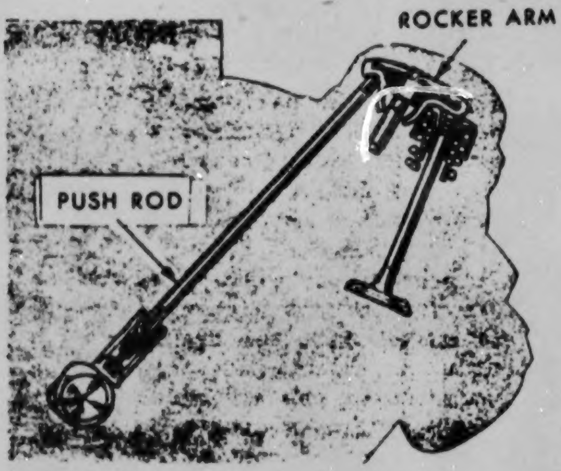

ROCKER ARM
PUSH ROD

Figure 7. Push Rods and Rocker Arm Linkages.

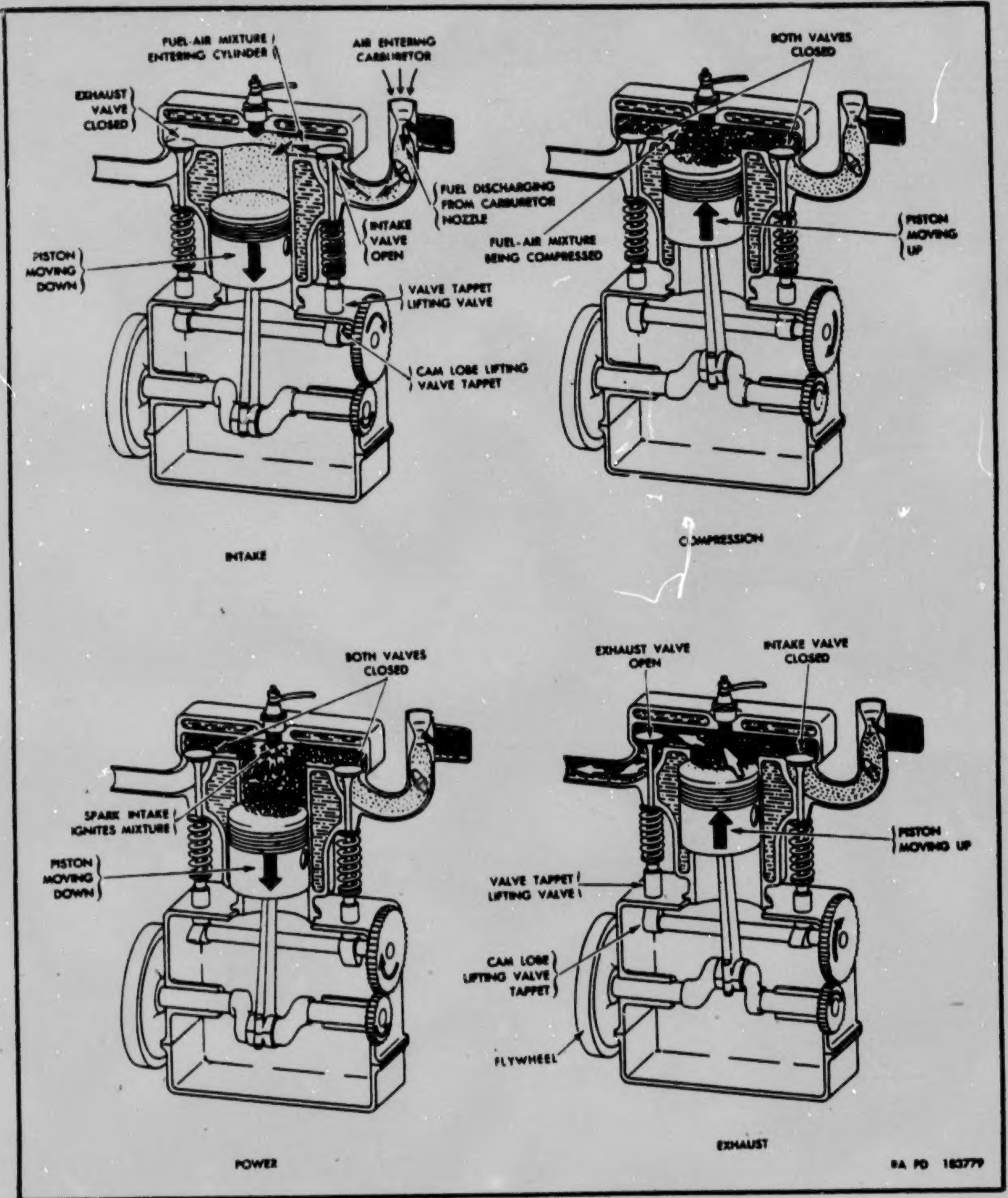

FUEL-AIR MIXTURE ENTERING CYLINDER
AIR ENTERING CARBURETOR
EXHAUST VALVE CLOSED
FUEL DISCHARGING FROM CARBURETOR NOZZLE
INTAKE VALVE OPEN
PISTON MOVING DOWN
VALVE TAPPET LIFTING VALVE
CAM LOBE LIFTING VALVE TAPPET
INTAKE
BOTH VALVES CLOSED
FUEL-AIR MIXTURE BEING COMPRESSED
PISTON MOVING UP
COMPRESSION
BOTH VALVES CLOSED
SPARK INTAKE IGNITES MIXTURE
PISTON MOVING DOWN
POWER
EXHAUST VALVE OPEN
INTAKE VALVE CLOSED
PISTON MOVING UP
VALVE TAPPET LIFTING VALVE
CAM LOBE LIFTING VALVE TAPPET
FLYWHEEL
EXHAUST
RA PD 183779

Figure 8. Four Stroke Cycle.

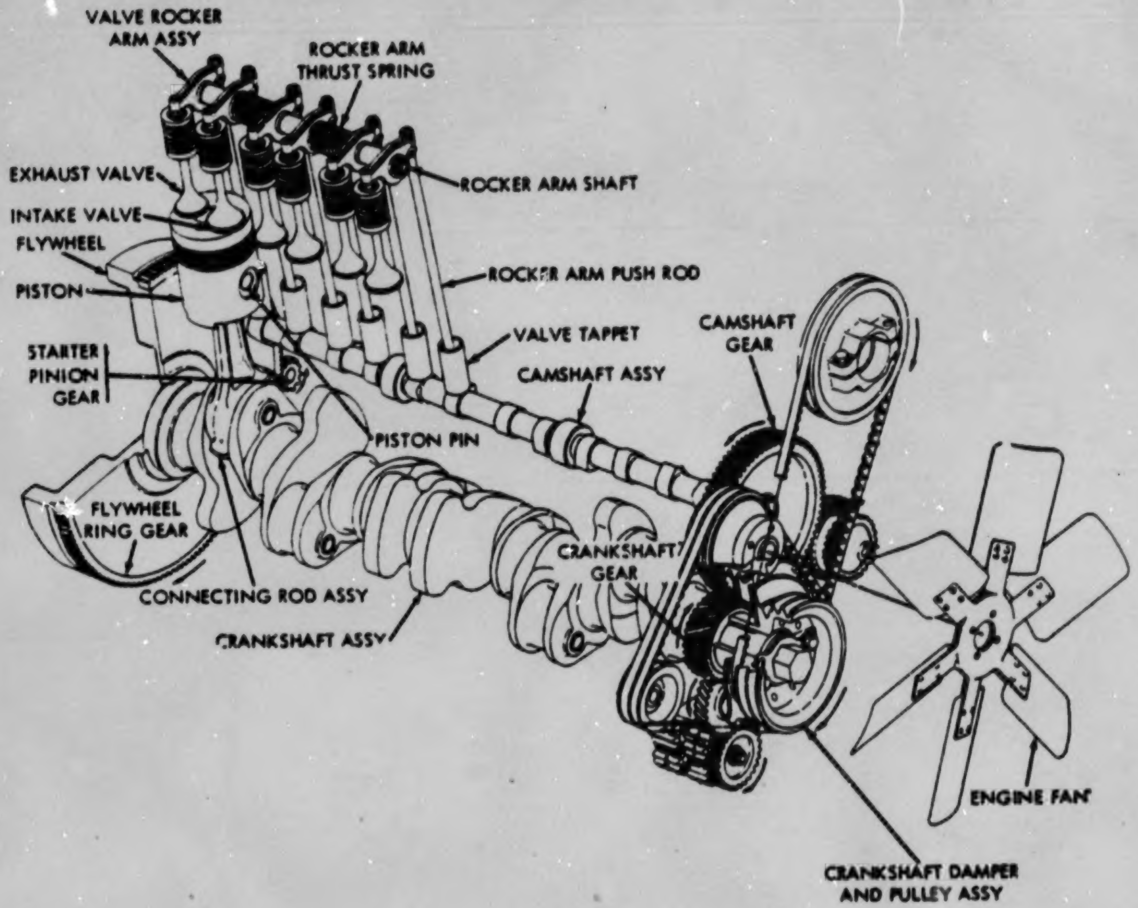

VALVE ROCKER ARM ASSY
ROCKER ARM THRUST SPRING
EXHAUST VALVE
ROCKER ARM SHAFT
INTAKE VALVE
FLYWHEEL
ROCKER ARM PUSH ROD
PISTON
CAMSHAFT GEAR
VALVE TAPPET
STARTER PINION GEAR
CAMSHAFT ASSY
PISTON PIN
FLYWHEEL RING GEAR
CRANKSHAFT GEAR
CONNECTING ROD ASSY
CRANKSHAFT ASSY
ENGINE FAN
CRANKSHAFT DAMPER AND PULLEY ASSY

Figure 9. Multi-Cylinder Assembly.

The previous paragraph describes a four stroke cycle engine. The four strokes, (1) intake, (2) compression, (3) power, (4) exhaust, occur over and over again in the same order. Each time these four strokes occur they produce one power impulse. The four strokes taken together equal one cycle. In order to store up enough momentum to keep the engine turning between power strokes, a large heavy disc is bolted to the rear end of the crankshaft. This disc is called a flywheel. Refer to figure 8 for an illustration of the four stroke cycle and the flywheel.

Each time a power impulse is produced, a sharp snapping action is transmitted to the crankshaft. These sudden power impulses applied to the crankshaft set up a twisting vibration which is called "torsional vibration." In order to lessen the effects of torsional vibration, a harmonic balancer or vibration damper is placed on the front of the crankshaft. This unit is not common to small engines but is usually a part of larger, multi-cylinder automotive engines. Refer to figure 9.

There is also a two stroke cycle engine that works as follows: Intake and exhaust ports are cut into the cylinder wall, and as

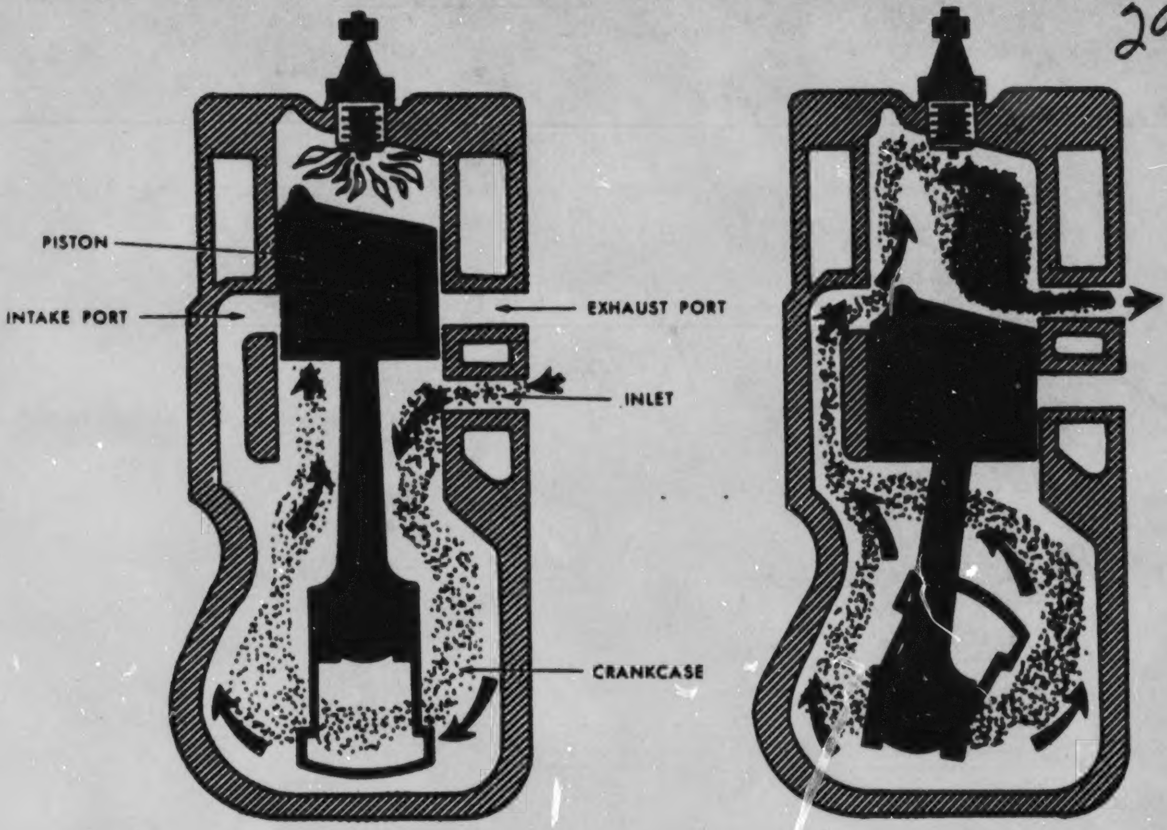


Figure 10. Events in a 2-Stroke-Cycle, Internal Combustion Engine.

the piston moves down on its power stroke, it first uncovers the exhaust port to allow burned gasses to escape. It then uncovers the intake port to allow a new air-fuel mixture to enter the combustion chamber. On the upward stroke, the piston covers both ports and, at the same time, compresses the new mixture in preparation for ignition and another power stroke. Refer to figure 10.

This chapter has dealt with and built up a one cylinder, four stroke cycle engine. However, automotive engines are multi-cylinder engines. Extra cylinders are added to produce a greater amount of, and a smoother flow of power. A four cylinder engine would produce a ralatively smooth flow of power, but there is no power overlap (one cylinder beginning a power stroke before another one has finished). However the more cylinders added, the greater the power overlap and the smoother the power flow.

Multi-cylinder automotive engines come in many different arrangements of parts, so it is necessary to classify these engines into catetories.

1. By Cooling System
    a. Air coaled engines
    b. Liquid cooled engines

2. By Cylinder Arrangement

a. In-line: All cylinders are assembled in a straight line above a common crankshaft which is just below the cylinders.

b. V-Type: In the V-type engines, two "blanks" of in line cylinders are mounted in a V-shape above a common crankshaft. The angle of the V is usually 90 degrees for an eight cylinder engine.

c. Horizontal Opposed: This engine has its cylinders laid on their sides in two rows with the crankshaft in the center.

3. By Valve Arrangement (Refer to Figure 11)

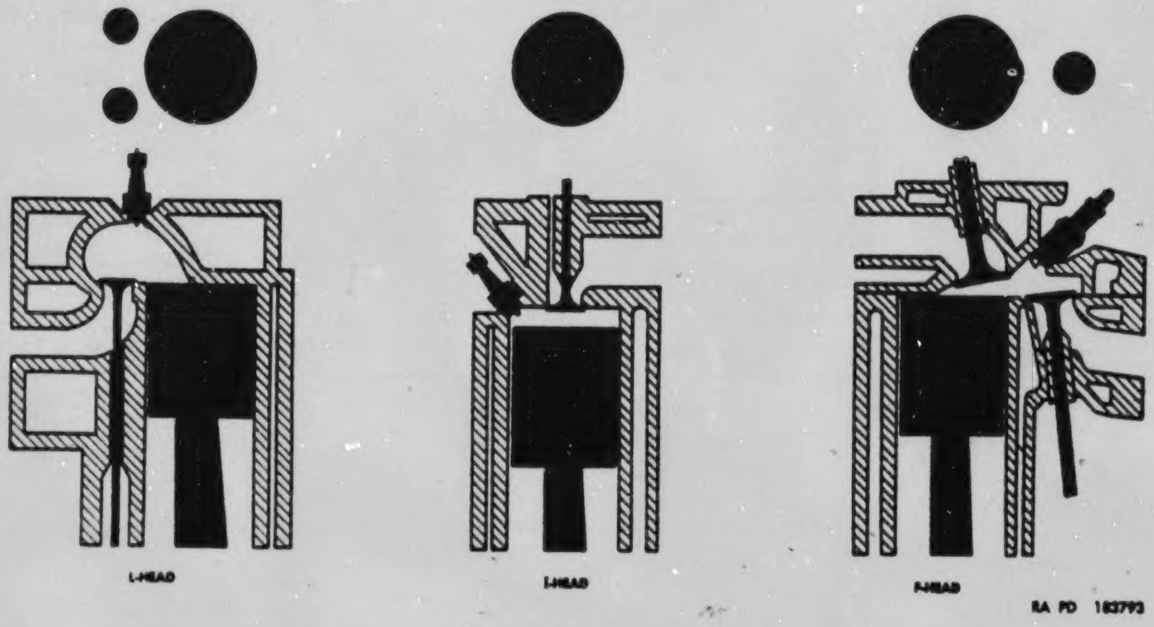


Figure 11. Valve Arrangement.

a. L-Head: Both valves are placed in the cylinder block on the same side of the cylinder. This is more commonly called a flathead engine.

b. I-Head: Commonly called valve in head or overhead valve engines, because the valves are mounted in the cylinder head above the piston.

c. F-Head: This arrangement is common to military type jeeps. The intake valve is in the head and the exhaust valve is in the block.

4. By Type of Fuel

a. Gasoline engines.

b. Diesel engines.

5. By Number of Strokes in a Cycle

   a. Two Stroke cycle.

   b. Four Stroke cycle.

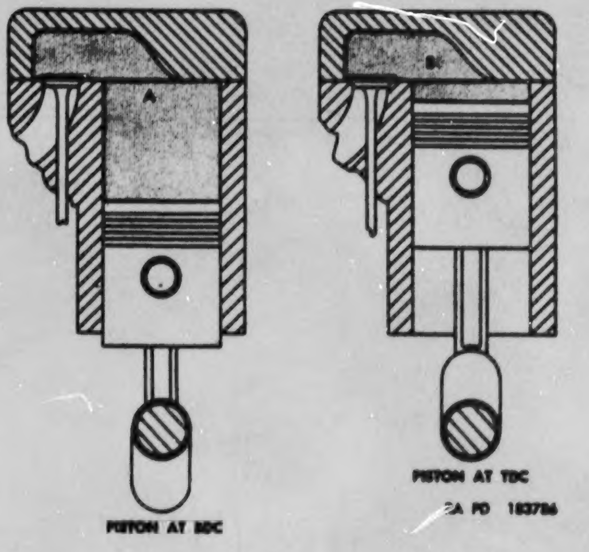


Figure 12. Compression Ratio is Ratio Between "A" and "B."

SUMMARY

This chapter has covered the areas of basic engine operation, principles of construction, and the function that each part or group of parts has in relation to engine operation. It is important to remember the theory behind the four-stroke cycle engine. This theory, plus a knowledge of terms such as volumetric efficiency, compression ratio, figure 12, pressure differentials, etc., are extremely significant and handy tools when a mechanic has to troubleshoot an engine malfunction.

QUESTIONS

1. Explain the relationship of vacuum, atmospheric pressure, and pressure differentials.

2. Explain the operation of a four stroke cycle engine.

3. How is valve operation related to piston movement?

4. How is valve timing accomplished?

5. What is the purpose of the crankshaft?

6. What is the purpose of the flywheel?

7. What is the difference between a four stroke cycle engine and a two stroke cycle engine?

8. What is the purpose of connecting rod and crankshaft bearings?

9. What is crankshaft end-play and how is it controlled?

10. What is "torsional vibration" and how is it controlled?

11. List the major classifications of internal combustion gasoline engines.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-202

ENGINE DISASSEMBLY, ENGINE COMPONENTS INSPECTION AND PARTS SERVICING, ENGINE REASSEMBLY, OPERATION AND VALVE ADJUSTMENT

OBJECTIVES

After completion of this unit of instruction you will be able to inspect engine components and determine their serviceability by comparision of inspection results with manufacturer's specifications.

INTRODUCTION

In this student study guide, a general outline for inspection and servicing of engine parts will be discussed. For specifications and specific methods of accomplishing the procedures that follow, it will be necessary to refer to the appropriate technical order or commercial manual.

INFORMATION

Safety precautions must come first at all times when working in maintenance shops and this school. Your instructor will be looking for such things as follows: proper use of tools; water or oil on the floor; removal of jewelry in lab areas; proper use of battery chargers; and care of all equipment.

CLEANING AND PARTS INSPECTION

Upon engine disassembly all parts should be cleaned and visually inspected for obvious defects such as: scratches, burning, scrapes, and breakage. Since such defective parts must be replaced, it won't be necessary to measure them for wear. Any special cleaning procedure will be discussed when the appropriate parts are mentioned.

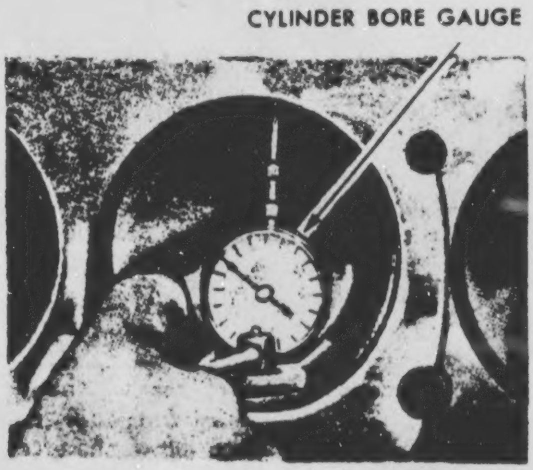


Figure 13. Cylinder Bore Gauge.

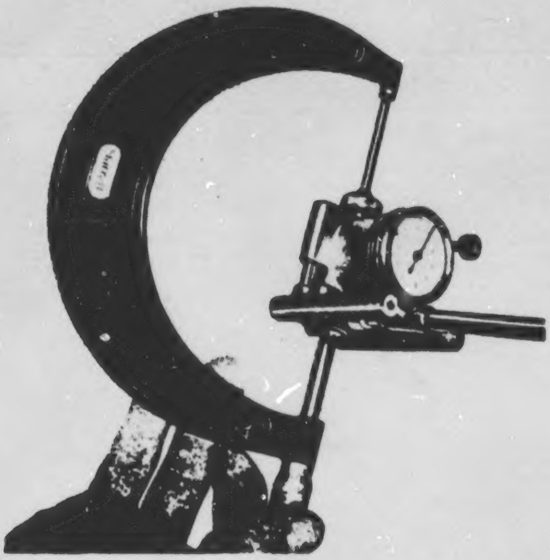


Figure 14. Checking Cylinder Bore With Gauge and Outside Micrometer.

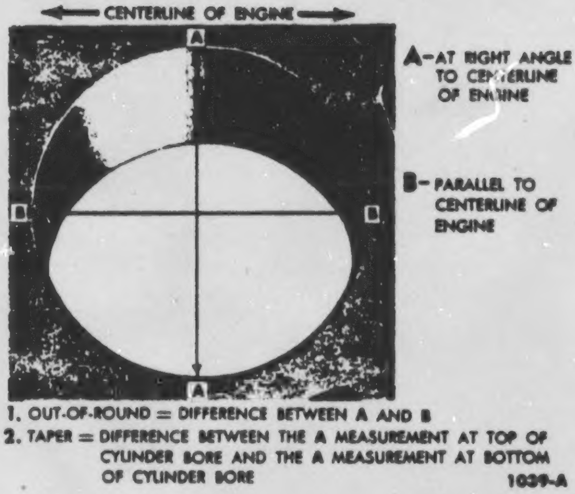

CENTERLINE OF ENGINE
A
A
B
B
A–AT RIGHT ANGLE TO CENTERLINE OF ENGINE
B–PARALLEL TO CENTERLINE OF ENGINE
1. OUT-OF-ROUND = DIFFERENCE BETWEEN A AND B
2. TAPER = DIFFERENCE BETWEEN THE A MEASUREMENT AT TOP OF CYLINDER BORE AND THE A MEASUREMENT AT BOTTOM OF CYLINDER BORE
1039-A

Figure 15. Checking Cylinder Bore Out-Of-Round.

Cylinder Blocks and Heads

The cylinder block and head should be carefully inspected for a buildup of rust and scale into coolant passages, or blocked oil passageways. The next step is to measure the cylinder itself to determine the following: (1) correct size (diameter), (2) cylinder tapered from the top to the bottom, and (3) cylinder out of round. These measurements are taken with a cylinder gauge and outside micrometers, or with a telescoping gauge and outside micrometers, and are illustrated in figures 13, 14 and 15. If the cylinders are slightly out of shape they can be corrected by using

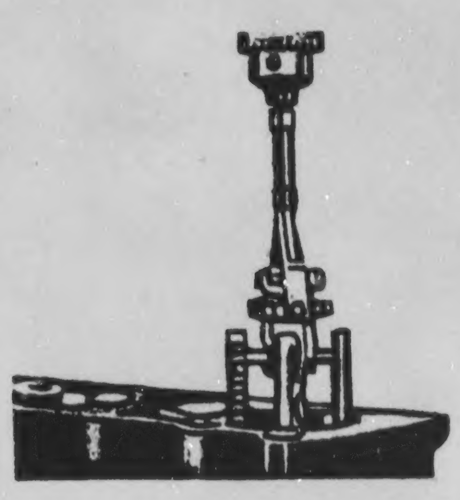


Figure 16. Cylinder Hone.

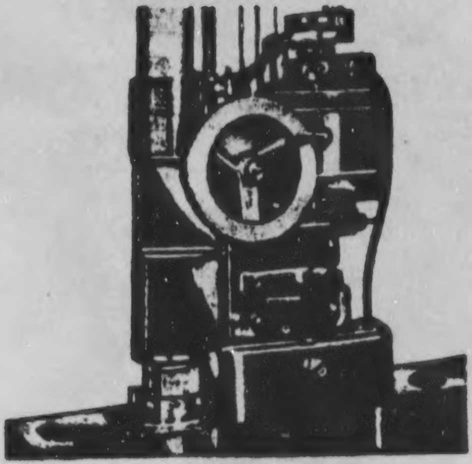


Figure 17. Boring a Cylinder.

Figure 18. Crosshatch Pattern On Properly Honed Cylinder Wall.

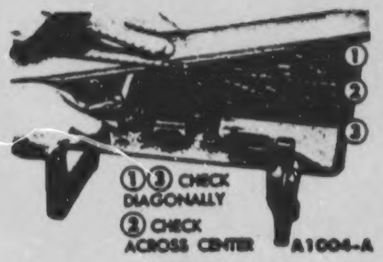


Figure 19. Cylinder Head Flatness.

a cylinder hone, figure 16. If, however, the cylinders become worn too much, it will be necessary to have them bored out as illustrated in figure 17. After the cylinder is bored, it must then be honed slightly to produce the correct finish on the cylinder walls, as shown in figure 18. Finally, the flatness of the top of the block should be checked. Figure 19 shows the flatness of a cylinder head. The same method of using a straightedge and feeler gauge would be applied to the cylinder block.

Pistons, Piston Rings and Connecting Rods

Pistons must be cleaned with an approved solvent and dried with compressed air. Do not scrape them with a putty knife or wire brush. The ring grooves of a piston are cleaned with a ring groove cleaner, as illustrated in figure 20. The next step is to measure the outside diameter of the piston to determine how

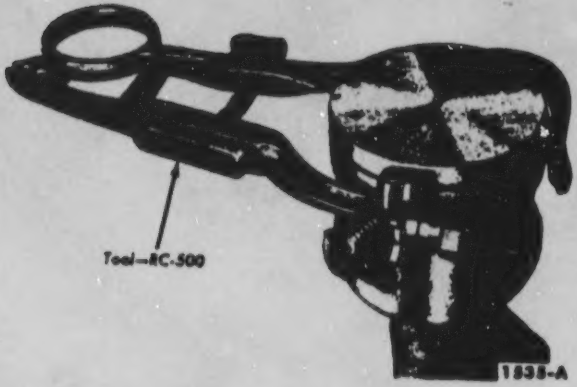


Figure 20. Cleaning Ring Grooves.

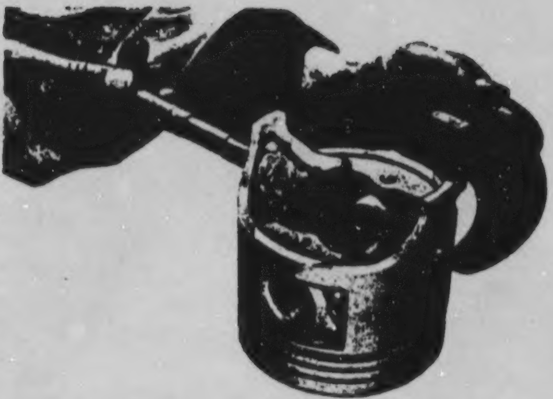


Figure 21. Measuring Piston with Micrometer.

much it is worn. This is done with an outside micrometer, as indicated in figure 21.

When both the cylinder diameter and the piston diameter are known, the clearance between them can be determined by subtracting the two measurements. For example:

Cylinder Bore = 4.000 inches

Piston Diameter = 3.994 inches

Difference = 0.006 inches

Clearance - .003 inches (three thousandths on each side)

Another way to check piston fit is with a ribbon and spring tension scale. Here you measure how many pounds of pull are required to pull the feeler ribbon out of the cylinder as illustrated in figure 22. The last thing to measure is the fit between the piston pin and the piston boss. This is accomplished by micing (using micrometer) to check the outside diameter of the piston pin and the inside diameter of the piston boss. The clearance is then determined in the same way

298

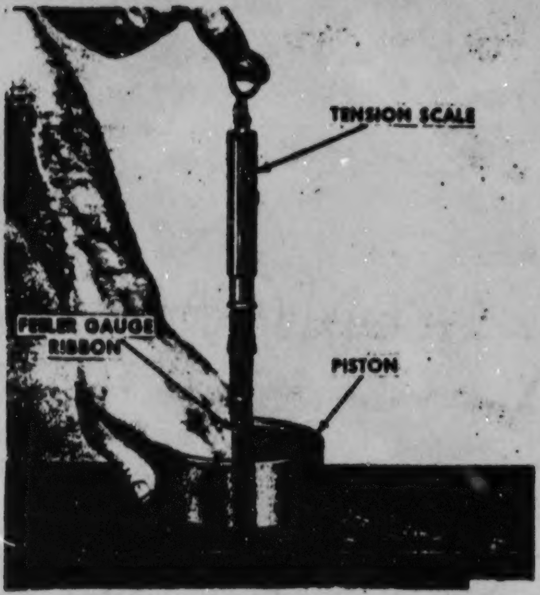


Figure 22. Checking Piston Fit to Cylinder Bore.

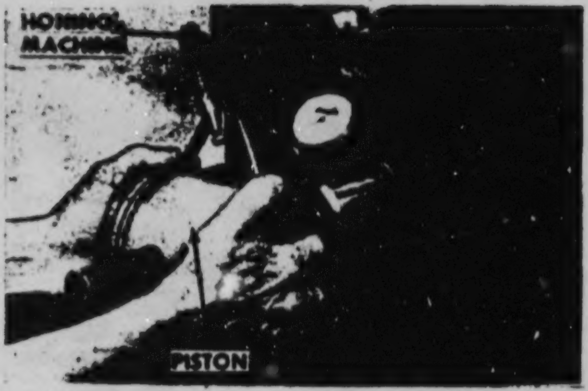


Figure 23. Honing Piston Pin Bosses.

as it was for piston fit. If the piston pin fit is incorrect, the piston must be replaced, or the piston bosses must be honed out so that a larger pin may be installed, figure 23.

The next group of ports to be inspected are the piston rings. The following items should be checked: (1) end-gap or the distance between the ends of the ring when it is at the bottom of ring travel, (2) side clearance, and (3) make sure the ring is free to turn in its groove on the piston. End-gap and side clearance are shown in figures 24 and 25. If there is too little end-gap, it can be increased by filing the ends of the ring. If there is too much end-gap, a larger ring will have to be installed. If too

317

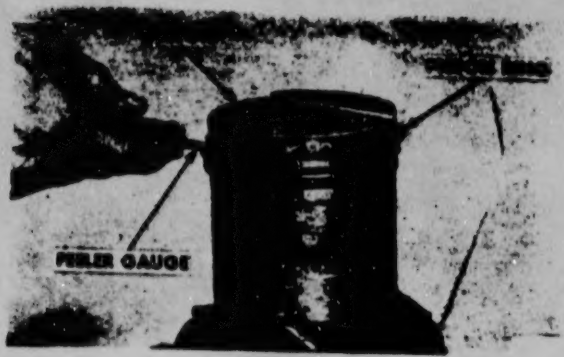


Figure 24. Checking Ring-to-Groove Side Clearance with Feeler Gauge.

Figure 25. Checking Ring Gap with Feeler Gauge.

much side clearance is detected be sure to inspect both the ring and the ring groove or ring bands of the piston. It's possible for the ring groove to become enlarged causing a sloppy fit even with a good ring.

Finally, it will be necessary to check the condition of the connecting rod. The first item to check is the piston pin fit. It may be measured in the same manner as it was when checking its fit in the piston. The next thing to inspect is the rod for a bent or twisted condition. Many different types of rod alignment devices are available. One such tool and its use are illustrated in figure 26.

Crankshaft and Bearings

To begin with, place the crankshaft in a set of V blocks so that the end main bearing journals rest in the V's. If the shaft

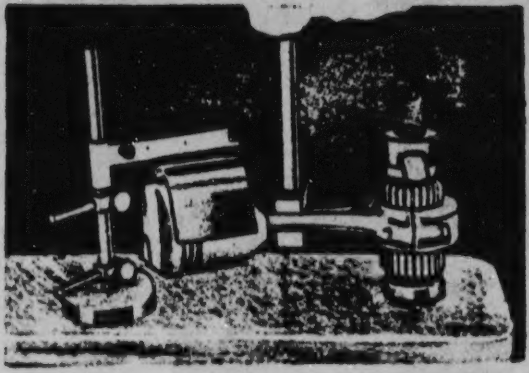


Figure 26. Rod Alignment Tool.

is bent or warped, the main bearing journals will not rotate in a true circle. This warpage can be detected by placing a dial indicator against the main bearing journals and rotating the shaft in the V blocks. This measurement is called crankshaft runout.

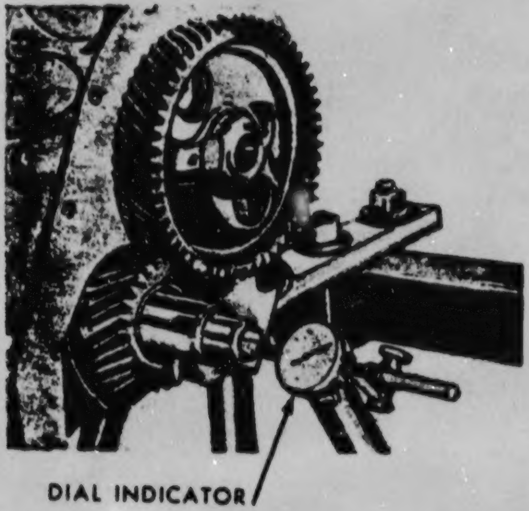


Figure 27. Dial Indicator.

The next item to check is crankshaft end-play. This is done by moving the shaft as far to the rear of the engine as possible (crankshaft installed in the cylinder block). Then set up a dial indicator as shown in figure 27. Finally, move the shaft all the way forward and read end-play on the dial indicator.

After end-play has been checked, the flywheel mounting surface of the crankshaft, and the face of the flywheel should be checked for runout. This is accomplished with a dial indicator as shown in figures 28 and 29.

When these measurements are completed it will be time to measure each and every crankshaft journal for the following: (1) diameter,

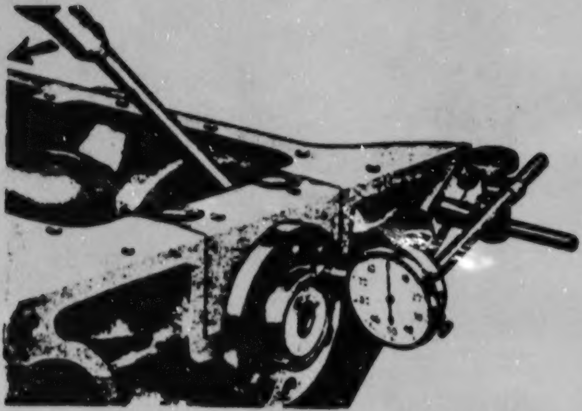


Figure 28. Checking Flywheel Mounting Surface Runout.

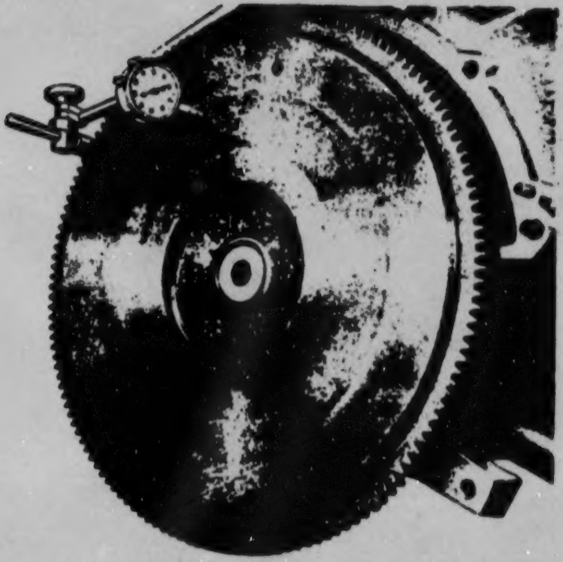


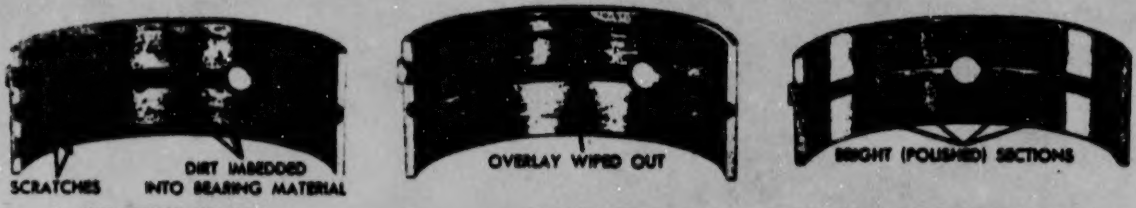
Figure 29. Typical Flywheel Face Runout.

(2) taper, (3) out of round. These measurements are taken with an outside micrometer. After diameter has been checked at one point, rotate the micrometer around the shaft 90° and check it again. If there is a difference in the two measurements, the journal is out of round the amount of that difference. The diameter of the journal is also checked on both ends in order to determine the amount of taper. If any of the above measurements are out of specifications, the crankshaft will have to be taken to a machine shop and be corrected or be replaced.

The last item to be inspected in regards to the crankshaft are main and connecting rod bearings. Since the same procedures apply to both, no distinction will be made between them. Study figure 30 to become familiar with common bearing failures.

Two things must be checked before installing a set of bearing inserts. First, the bearing spread or distance between the ends

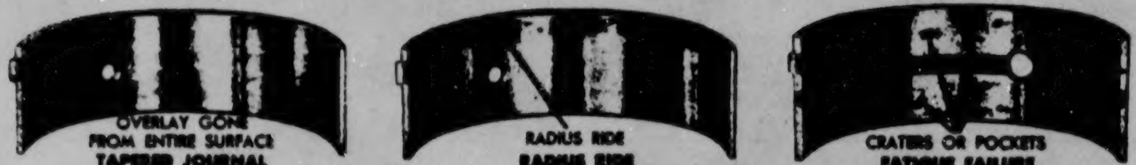
302


SCRATCHES
DIRT IMBEDDED INTO BEARING MATERIAL
OVERLAY WIPED OUT
BRIGHT (POLISHED) SECTIONS

SCRATCHED BY DIRT

LACK OF OIL

IMPROPER SEATING


OVERLAY GONE FROM ENTIRE SURFACE
RADIUS RIDE
CRATERS OR POCKETS

TAPERED JOURNAL

RADIUS RIDE

FATIGUE FAILURE

Figure 30. Typical Bearing Failures.

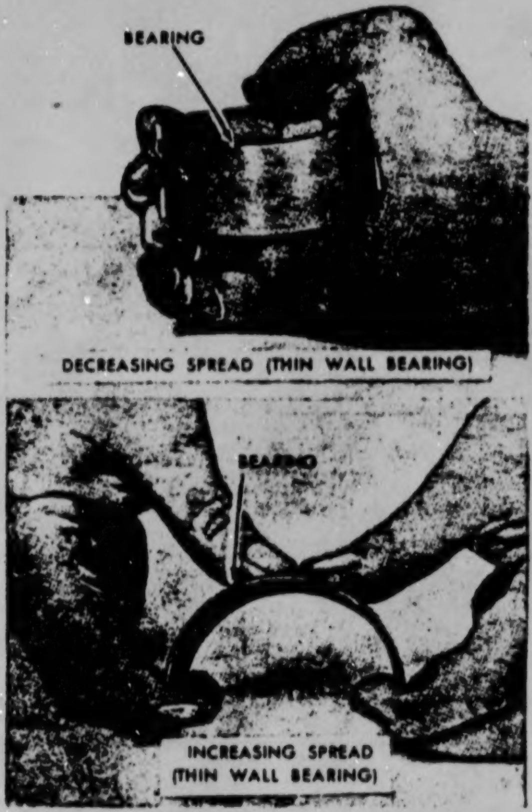

BEARING
DECREASING SPREAD (THIN WALL BEARING)
BEARING
INCREASING SPREAD (THIN WALL BEARING)

Figure 31. Bearing Spread Adjustment.

of the bearing, and bearing clearance (the space between the bearing and the crankshaft journal where oil circulates). The method of adjusting bearing spread is illustrated in figure 31. To measure bearing clearance, a small rod of soft plastic (Plastigage) is used. A piece of plastigage is placed across and just a little off

321

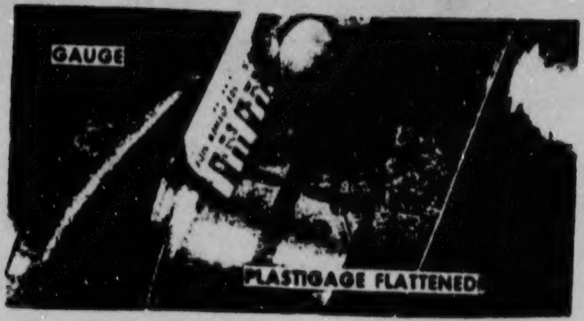

GAUGE
PLASTIGAGE FLATTENED

Figure 32. Checking Bearing Clearance.

center on the bearing. Then install the bearing and bearing cap in the engine and torque the bolts down to specifications. Do not turn the crankshaft with the plastigage installed. Next, remove the bearing cap and check the width of the flattened plastigage with the scale provided as shown in figure 32. The scale reads bearing clearance directly in thousandths of an inch.

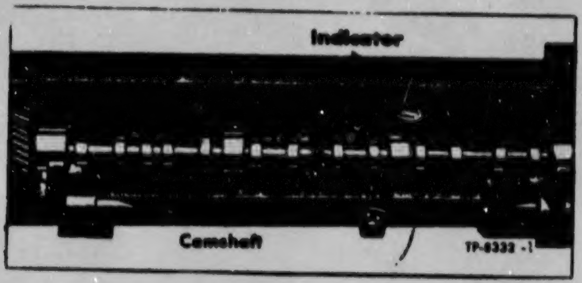

Indicator
Camshaft
TP-8332 -1

Figure 33. Checking Camshaft Runout with Indicator and V-Blocks.

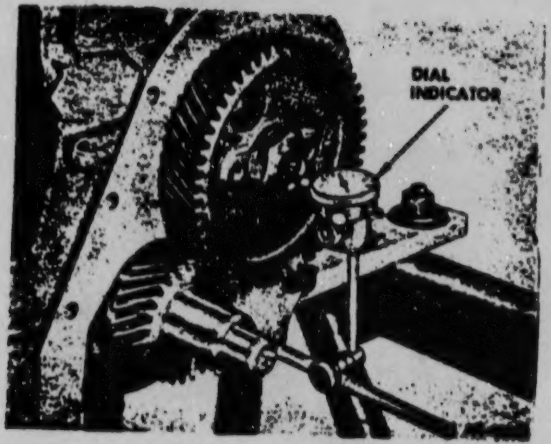

DIAL INDICATOR

Figure 34. Checking Camshaft End Play.

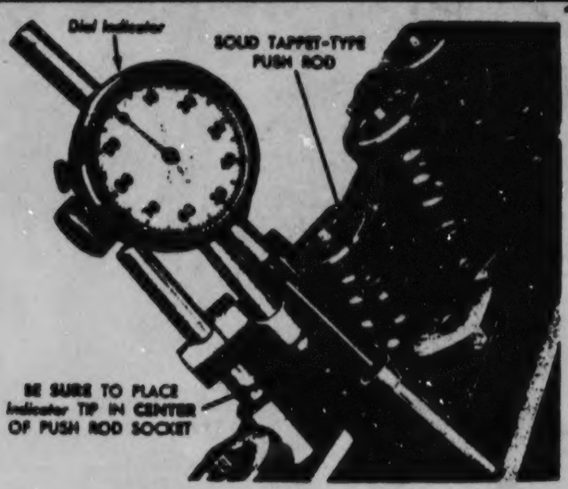

Dial Indicator
SOLID TAPPET-TYPE PUSH ROD
BE SURE TO PLACE Indicator TIP IN CENTER OF PUSH ROD SOCKET

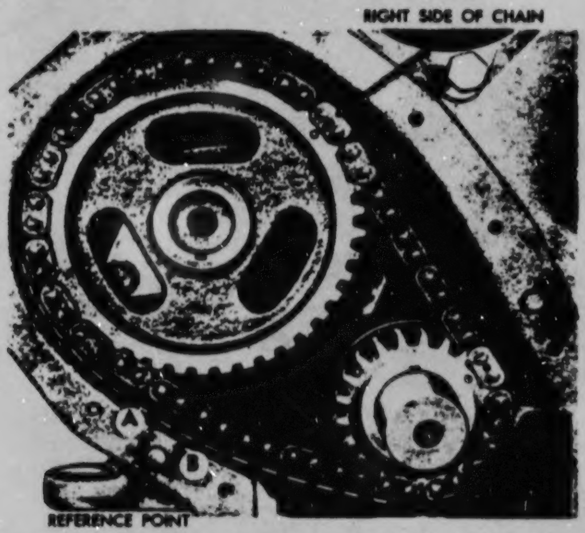
Figure 35. Checking Cam Lobe Lift.

Camshaft and Bearings

Checking a camshaft is very similar to checking a crankshaft. The bearing journal, camshaft runout, and end-play are checked in exactly the same manner as the crankshaft. Runout and end-play are pictured in figures 33 and 34.

In addition to these measurements, the amount of cam lobe lift must also be checked. This can be done with the shaft in V Blocks and a dial indicator mounted against the lobe, or by using the dial indicator on the end of a pushrod, as shown in figure 35.

Finally, the bearing clearance is measured by using an outside micrometer to measure the bearing journal and inside micrometers to measure the bearing. Review the subject of measuring the clearance of the piston to the cylinder wall for details.


RIGHT SIDE OF CHAIN
A
B
REFERENCE POINT

TAKE UP SLACK ON LEFT SIDE. ESTABLISH A REFERENCE POINT AND MEASURE DISTANCE A. TAKE UP SLACK ON RIGHT SIDE AND FORCE LEFT SIDE OUT WITH THE FINGERS AND MEASURE DISTANCE B. DEFLECTION IS A MINUS B.

Figure 36. Checking Amount of Slack

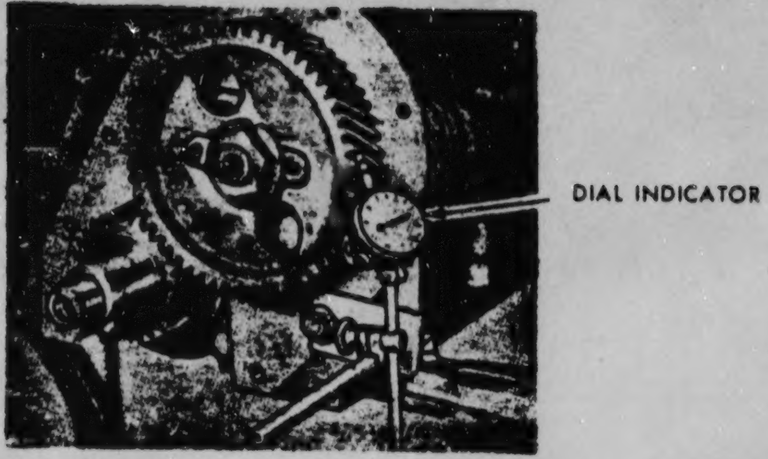


Figure 37. Dial Indicator.

Timing Gears and Chains

If the timing gears are connected with a chain, it will be necessary to measure the amount of slack in the chain with a steel rule. One manufacturer's method of doing this is shown in figure 36. If the gears are meshed together directly, the amount of play between the teeth, or backlash, is checked by inserting a feeler gauge between the teeth or by using a dial indicator as illustrated in figure 37.

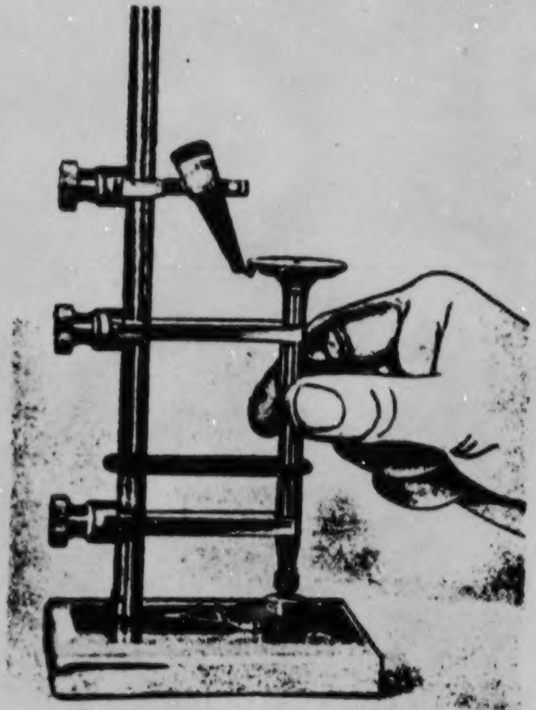


Figure 38. Checking Valve Measurements.

In order to clean valves, a wire brush on a bench grinder is normally used. The valves should then be visually inspected for evidence of burning, stems checked for scuffs, worn keeper grooves or bends. When these visual inspections are completed the following measurements should be accomplished: (1) diameter of the valve stem with outside micrometers, (2) thickness of the margin on the valve head with a steel rule, and (3) the runout of the valve face as illustrated in figure 38. (A dial indicator can also be used.)

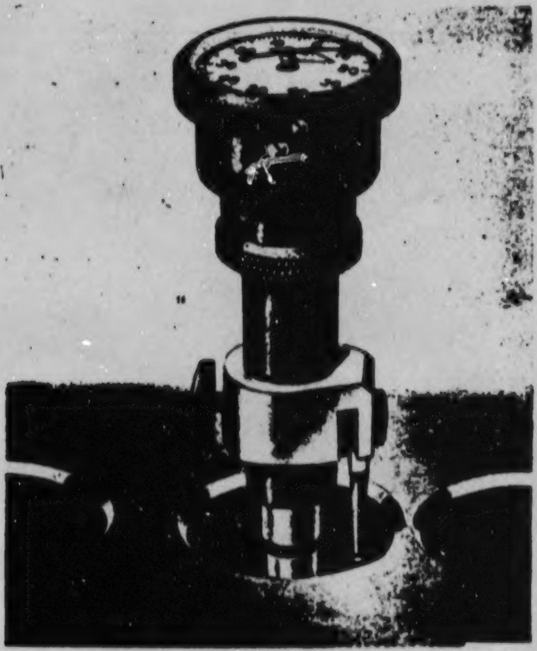


Figure 39. Valve Seat Runout.

The valve seats are the next items to be checked. Visually inspect the seats to see if they are battered, cracked, or pitted. If no defects are found then install a dial indicator and check the runout of the valve seat as shown in figure 39.

The valve guides may either be replaceable inserts or merely bored holes in the head. If the guides are bored holes in the head, and become worn, they must be rebored and valves with larger stems installed. Before inspecting the valve guides they should be cleaned with a special bursh attached to a 1/4 inch drill as shown in figure 40.

The next step is to measure the guide bore for wear. This can be accomplished by using inside calipers and an outside micrometer or a special gauge as illustrated by figure 41.

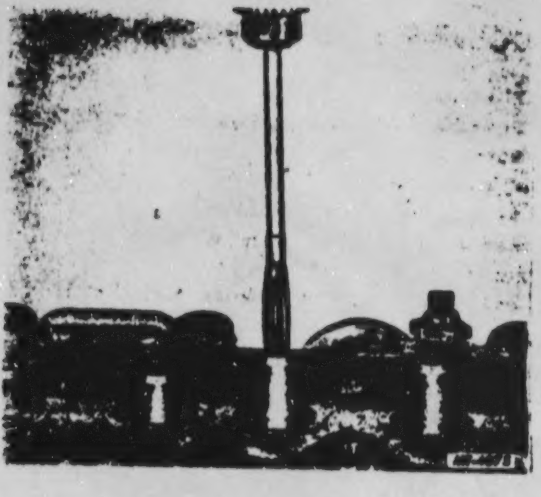


Figure 40. Cleaning Valve Guide Bores.

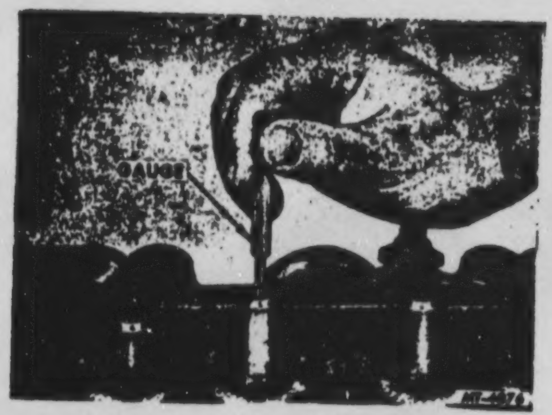


Figure 41. Checking Valve Guide Bore Using Gauge SE-1826.

After cleaning and measuring the guide bore, it will be necessary to check the clearance between the valve stem and the guide bore. The best way to make this check is by installing the valve in the valve guide and setting a dial indicator against the valve stem as pictured in figure 42. Then by moving the valve stem back and forth, the clearance can be determined from the dial indicator. An example of a worn guide and its results are shown in figure 43.

Checking the valve springs is the next item to consider. The springs should be straight and the coils not pulled out of shape. The ends of the springs should be square and flat. And finally, each spring should produce a specified amount of tension or pressure at a given height. This last item is checked with a valve spring tester as illustrated in figure 44.

Inspection of the parts that make up the valve operating mechanism is the final job to be performed. On vehicles with the rocker arms set up to operate on a shaft, two things must be checked. First, inspect the rocker arm shaft to see if it is warped, and

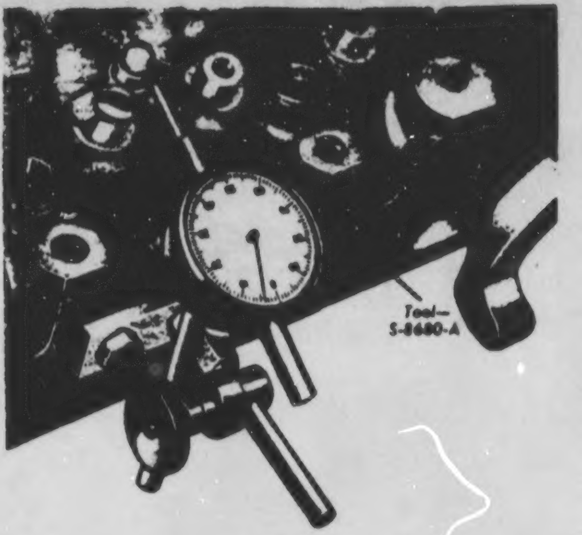


Figure 42. Typical Valve Stem Clearance.

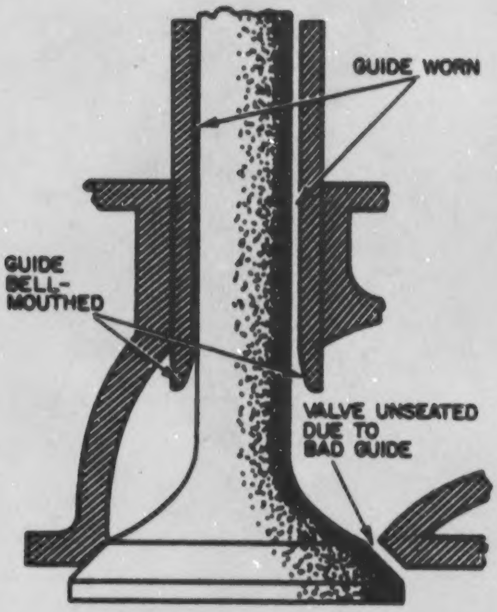


Figure 43. Effects of Worn Valve Guides.

second, measure the clearance between the rocker arm bushings and the rocker arm shaft. These checks can be made with a dial indicator and micrometers, and are performed in the same manner as they were when the camshaft was measured. If the engine in question does not use a rocker arm shaft, it will be necessary to inspect the individual studs that serve as a mount for each rocker arm. Make sure they aren't bent, partially pulled out of the cylinder head, or have damaged threads. When these items are completed, each rocker arm is inspected to make sure the part that contacts the valve stem is not marred and that the adjusting screws are not

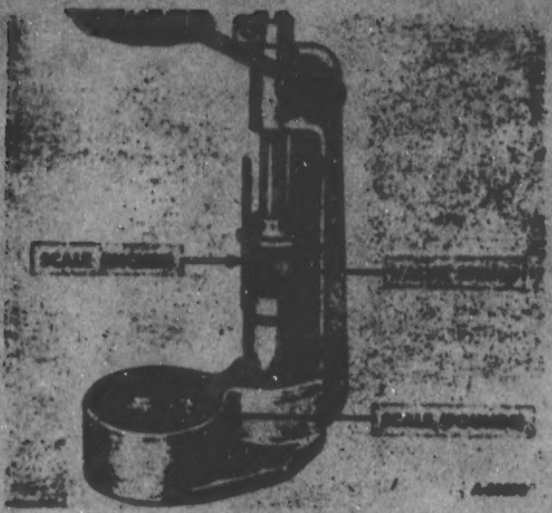


Figure 44. Checking Valve Spring Tension.

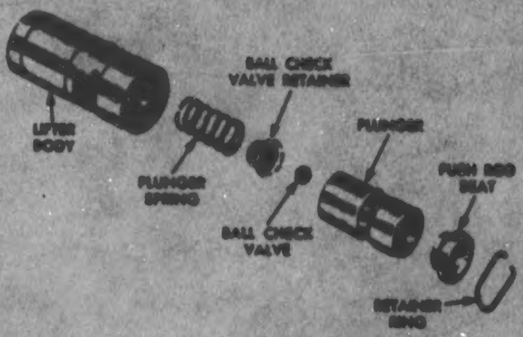


Figure 45. Exploded View of Valve Lifter.

damaged or have worn or stripped threads. The next items on the list are the pushrods. Check each one for battered or broken ends, and check each one to make sure it isn't bent. The last items on the list are the valve lifters. If the engine has solid lifters, visually inspect each one for damage and measure its running clearance in the cylinder block with micrometers and telescoping gauge. If the engine in question has hydraulic lifters, they should be disassembled, cleaned, and their leak down rate tested. These procedures are in addition to the ones mentioned for solid lifters. When cleaning hydraulic lifters, great care must be taken to insure that the parts of one lifter are not installed in any lifter body other than the one they were taken from. These parts are matched at the factory and are not interchangeable. A typical hydraulic lifter is shown in figure 45.

The leak down rate is tested by putting the hydraulic lifter in a special tester as shown in figure 46. The lifter is then pumped up with oil and the amount of time it takes for the lifter to leak down is measured in seconds.

310

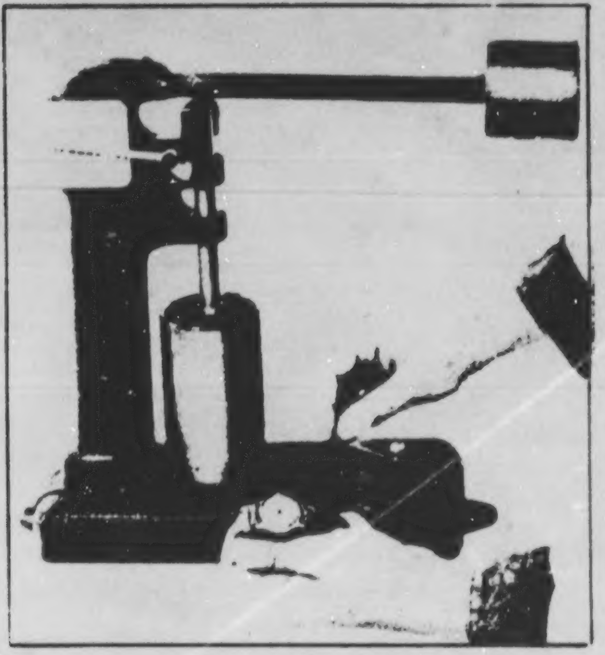


Figure 46. Testing Leak-Down Rate.

Seals and Gaskets

When repairing an engine there is only one rule to follow in regard to seals and gaskets, replace the old ones with new ones. Never reuse a gasket or seal.

When installing gaskets and seals, take great care to insure that they are put on the correct way and with the correct side facing up or out. Always consult the manufacturers manual, or the instructions that are included with the gaskets or seals.

SUMMARY

This chapter has dealt with the inspection of engine parts during overhaul or the repair of any given set of component parts. After reading and studying this chapter, review the inspection procedures and note the similarities of the different measurements involved.

QUESTIONS

1. Describe the procedures used to determine the serviceability of cylinder blocks and bores.

2. What are three things to check when installing piston rings?

3. Why must rod alignment be checked?

4. What items are inspected to insure the serviceability of a crankshaft?

5. How is a camshaft checked?

6. What are two ways to measure timing gear backlash?

7. How would you check a crankshaft, camshaft, rocker arm shaft and pushrod to see if they were bent or warped?

8. Why should the ring bands or ring groove of a piston be visually inspected if too much piston ring side clearance is detected?

9. How would the clearance between a rocker arm and rocker arm shaft be measured?

10. What checks are performed on hydraulic valve lifters?

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-203

PRINCIPLES, INSPECTION & REPAIR OF COOLING, LUBRICATION, & CRANKCASE VENTILATING SYSTEMS, & THE USE OF VALVE RECONDITIONING EQUIPMENT

OBJECTIVES

After completing this unit of instruction you will be able to explain the operation of cooling, lubricating, and crankcase ventilating systems and how to repair the common malfunctions of these systems.

INTRODUCTION

The purpose of the cooling system is to keep an engine at its most efficient operating temperature by removing the excess heat of combustion.

The lubricating system is primarily designed to supply a sufficient volume of oil under pressure to all moving engine parts. However, this system also cleans the engine internally, aids the cooling system by absorbing heat, and it makes a good seal between the piston rings and cylinder wall possible.

The engine's crankcase ventilating system has the job of removing harmful gasoline and water vapors from the lubricating oil in the crankcase.

COOLING SYSTEMS

Liquid Cooling Systems

The liquid coolant is circulated through the engine by a water pump, as shown in figure 47. While the coolant is moving through the engine's water jackets and passages it absorbs excess heat and retains it until it reaches the radiator. When the coolant reaches the radiator it flows through thin metal water tubes as illustrated in figure 48. These water tubes are spaced so that air can circulate around them and cool the liquid inside. During highway operation, air is forced through the radiator by the vehicle's forward motion. However, around town and when the vehicle is not moving, a fan attached to the water pump pulls air through the radiator to cool the liquid inside. After the temperature of the coolant is reduced in the radiator, it then returns to the water pump and into the engine. A typical water pump is illustrated in figure 49. When installed, this pump is driven by means of a pulley and fan belt attached to the fan hub. A constant coolant temperature is maintained by controlling the amount of coolant that circulates between the engine and radiator. This is accomplished by using a heat sensitive valve called a thermostat. When the engine is too cool, the valve closes and restricts the amount of coolant going to the radiator; and when the engine is too warm, it opens wider to allow more coolant to circulate through the radiator. This operation is shown in figures 50 and 51.

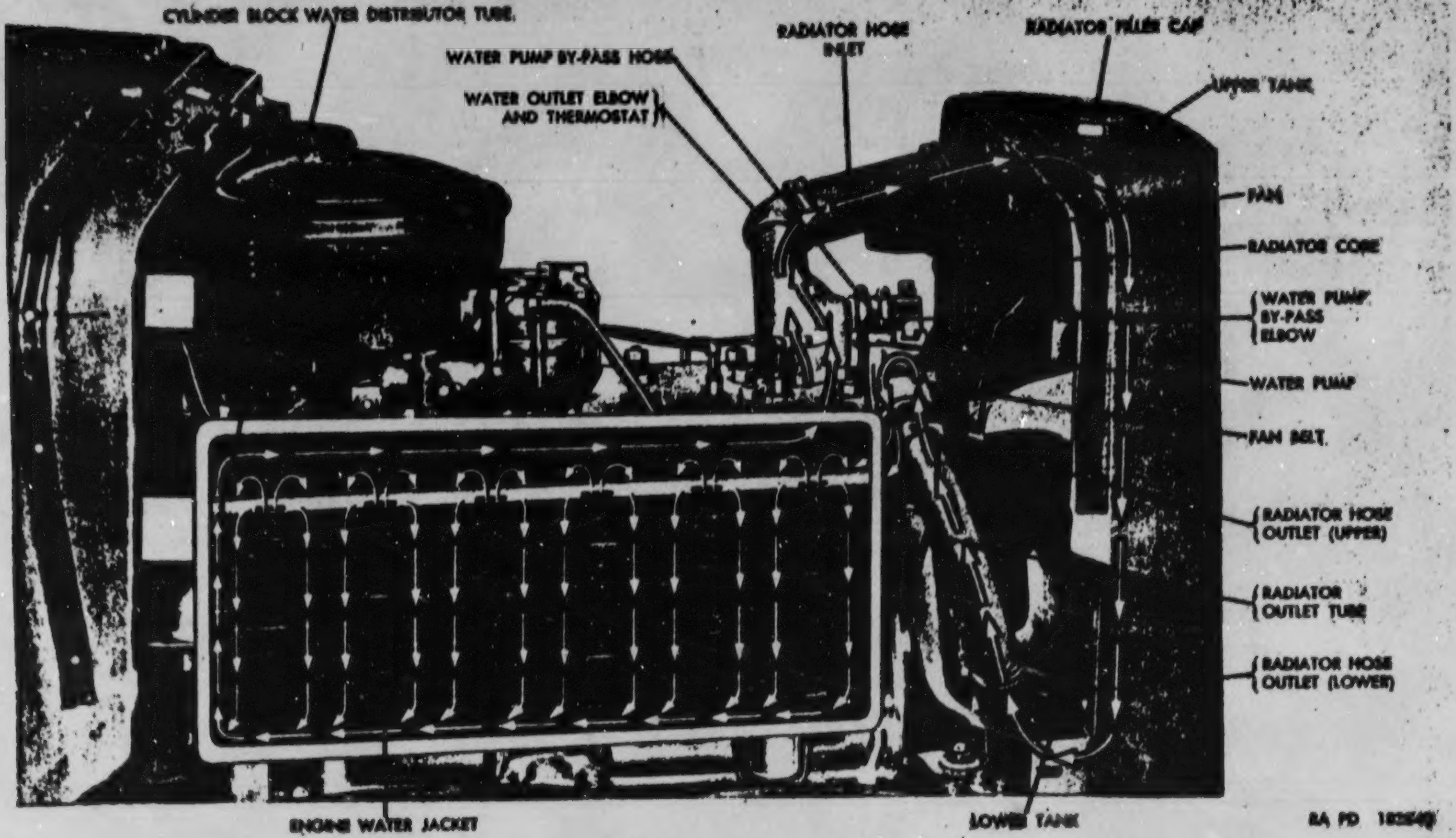

CYLINDER BLOCK WATER DISTRIBUTOR TUBE.
WATER PUMP BY-PASS HOSE
WATER OUTLET ELBOW AND THERMOSTAT
RADIATOR HOSE INLET
RADIATOR FILLER CAP
UPPER TANK
FAN
RADIATOR CORE
WATER PUMP BY-PASS ELBOW
WATER PUMP
FAN BELT.
RADIATOR HOSE OUTLET (UPPER)
RADIATOR OUTLET TUBE
RADIATOR HOSE OUTLET (LOWER)
ENGINE WATER JACKET
LOWER TANK
RA PD 182640

Figure 47. Cooling System Circulation.

314

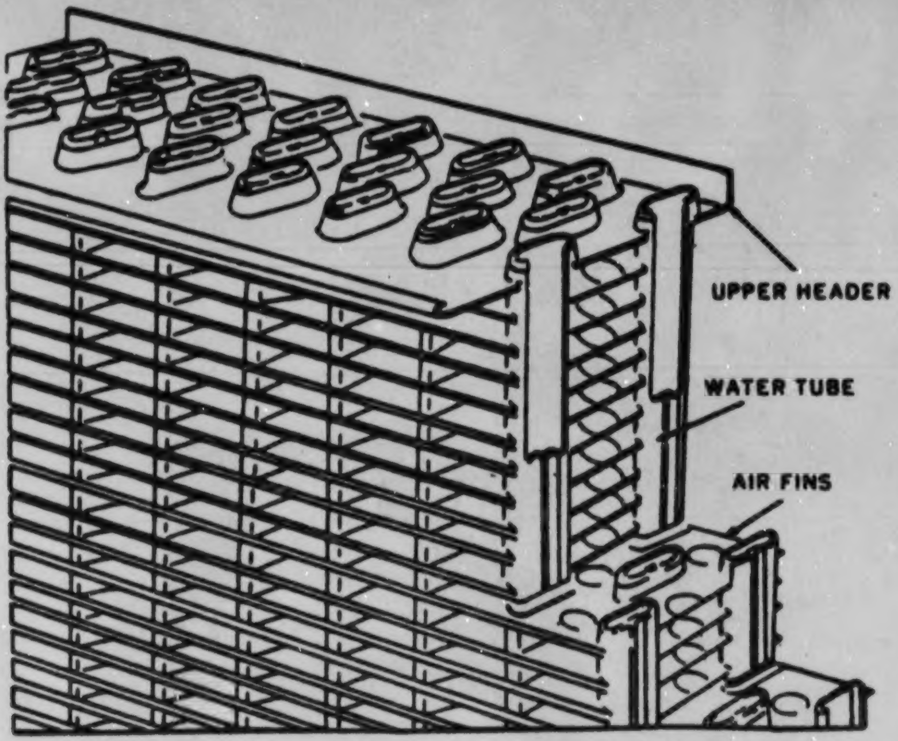

UPPER HEADER
WATER TUBE
AIR FINS

Figure 48. Tubular Core Radiator Construction.

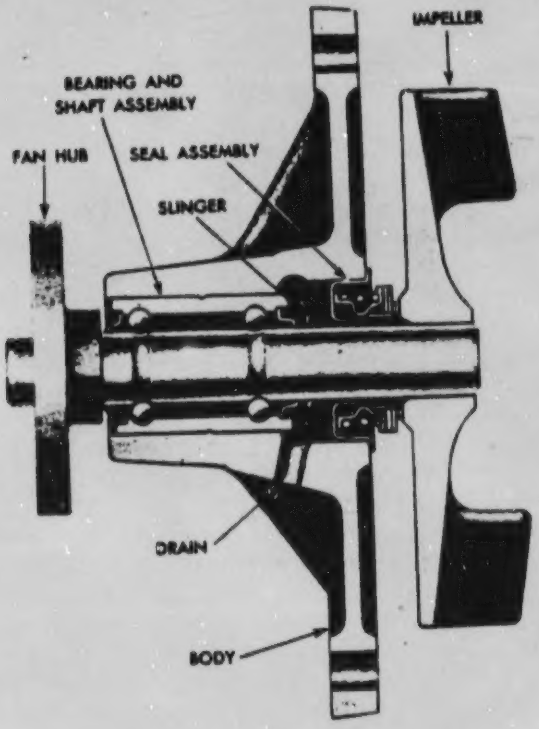
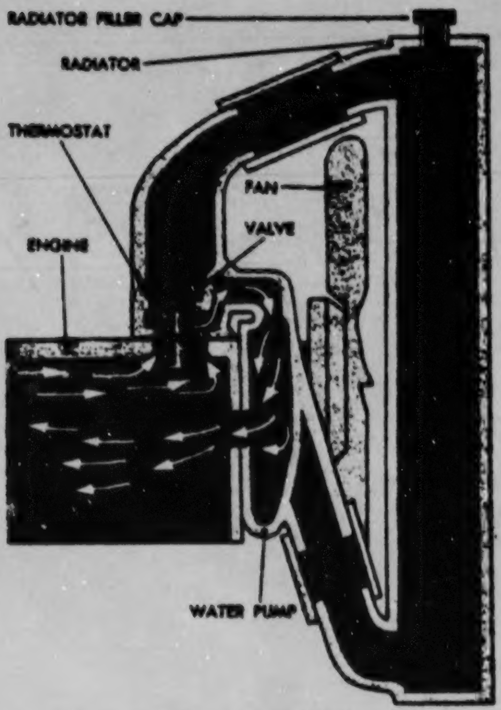

IMPELLER
BEARING AND SHAFT ASSEMBLY
FAN HUB
SEAL ASSEMBLY
SLINGER
DRAIN
BODY

Figure 49. Typical Water Pump.



ENGINE COLD—VALVE CLOSED BY THERMOSTAT ALLOWS WATER TO CIRCULATE THROUGH THE ENGINE BUT NOT THE RADIATOR

Figure 50. Thermostat Closed.

Notice that when the engine is cold and the thermostat is closed, figure 50, that the coolant is still allowed to circulate through the engine and water pump by means of a water pump bypass. This circulation prevents hot spots from developing where the coolant is close to the combustion chambers and exhaust valves. The next item to consider is the pressure radiator cap. Generally, the boiling point of the coolant is too close to the most efficient engine operating temperature. However, for every 1 pound of pressure applied to the coolant, its boiling point will be raised approximately 3°. Therefore cooling systems are designed to operate under pressure so that the engine can operate at its most efficient temperature without fear of the coolant boiling. The radiator pressure cap is designed so that any excess pressure will be allowed to escape through a radiator overflow pipe. The cap also contains a vacuum valve. This valve is necessary because the coolant contracted (shrinks) as it cools down after the engine is shut off. This contraction creates a vacuum inside the system and if air was not allowed to enter and relieve the vacuum, the hoses and even the top radiator tank might collapse. The most available coolant is of course water. However water alone will create rust and scale deposits that can block coolant circulation and cause an overheat condition. Therefore if water is all that is used in a cooling system, make sure a rust inhibitor and water pump lubricant are

314

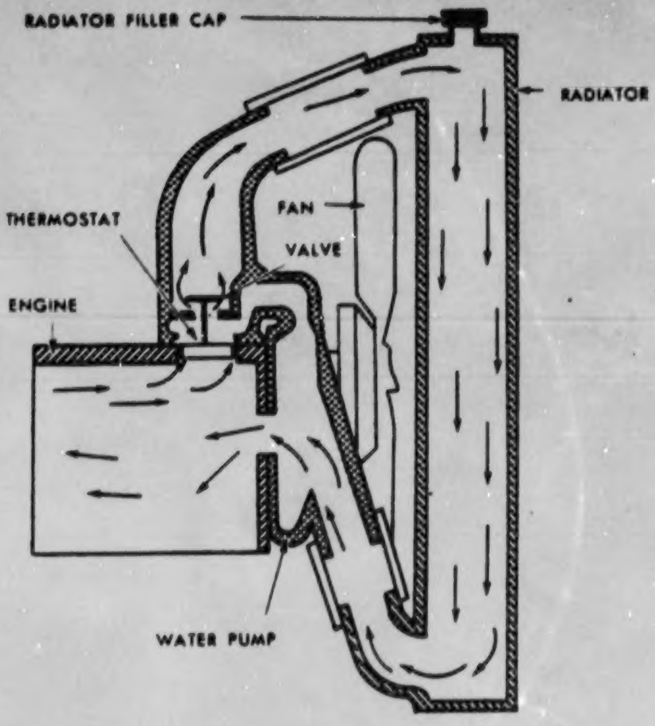


Figure 51. Thermostat Open.

added. Winter operation requires the use of an antifreeze solution. (Eythelene glycol is the chemical used.) Most commerical antifreeze already contains rust inhibitors and water pump lubricants and they tend to have higher boiling points than water so they are usually recommended for summer use also. On 1969 and later models, most manufacturers recommend that cooling systems be protected with antifreeze (eythelene glycol) to at least 0° F to provide adequate corrosion protection and proper operation of the temperature indicating light. Coolants that do not meet this requirement will boil at lower temperature than the setting for the indicating light.

Malfunctions and Repair

One of the most common causes of improper cooling system operation is a loss of coolant due to leaks. Leaks that occur due to a bad radiator cap, poor hose connection, or defective core hole plugs are repaired by replacing the defective part. Leaks are also caused by defective gaskets at the water pump, thermostat housing, or the head gasket. When replacing these gaskets, be sure and check the mating surfaces for warpage. Radiator leaks can usually be repaired by removing the radiator and soldering the leaks shut. If, however a leak occurs due to a cracked head or block, the defective part must be replaced. Examples of a cracked head or block are shown in figures 52 and 53.

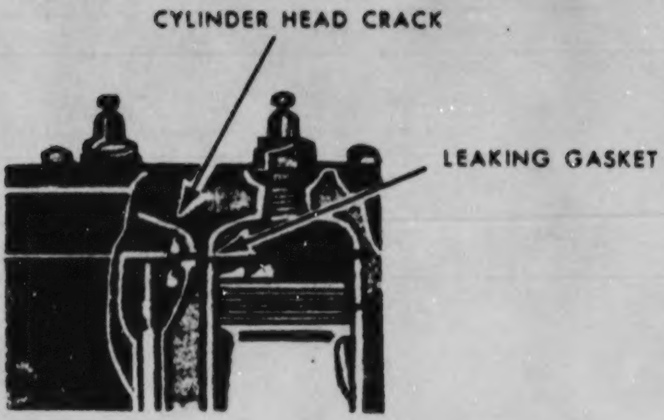

CYLINDER HEAD CRACK
LEAKING GASKET

Figure 52. Cracked Cylinder Head.

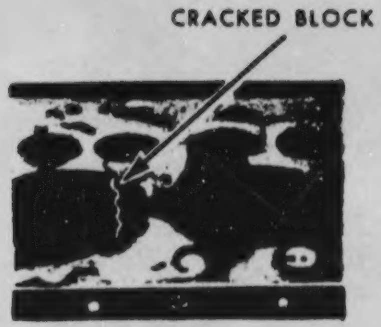

CRACKED BLOCK

Figure 53. Cracked Cylinder Block.

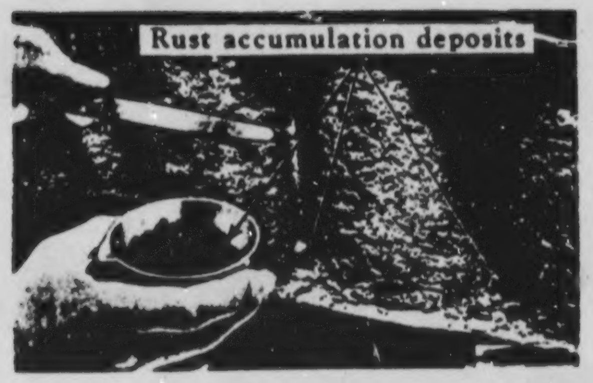

Rust accumulation deposits

Figure 54. Cross Section of Engine Showing Cooling System Neglect.

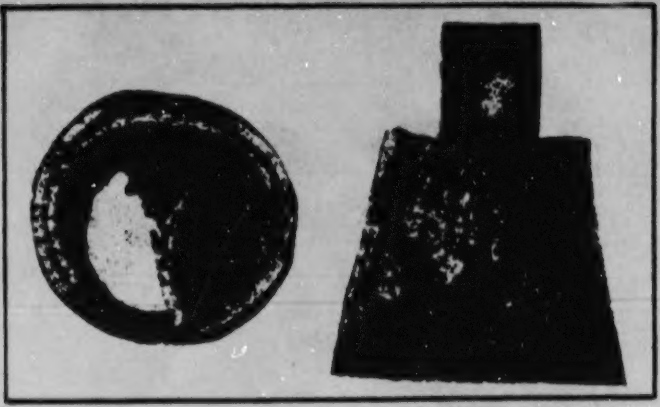


Figure 55. Inside Deterioration and Clogging of Rubber Hose.

Another type of problem that can develop in a liquid cooling system is blockage. When coolant passageways become blocked, the liquid can't circulate through the system and reach the radiator to be cooled. Therefore, an overheat condition may be experienced. This condition can be caused by a thermostat that does not open properly, but more often than not, is caused by cooling system neglect. That is, the system isn't drained and flushed periodically, hoses aren't inspected, or plain water is used for coolant without the addition of rust inhibitors and water pump lubricants. The results of such neglect are pictured in figures 54 and 55. If a defective thermostat is suspected, simply remove it from the engine and place it in a container of hot water with a thermometer. The thermostat should start to open when the water reaches the temperature rating of the thermostat being tested. This procedure is illustrated in figure 56.

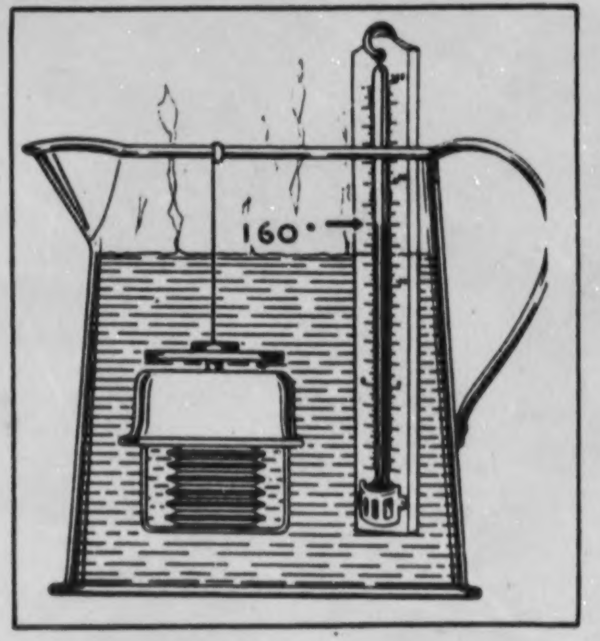


Figure 56. Simple Shop Test for Checking Thermostat Operation.

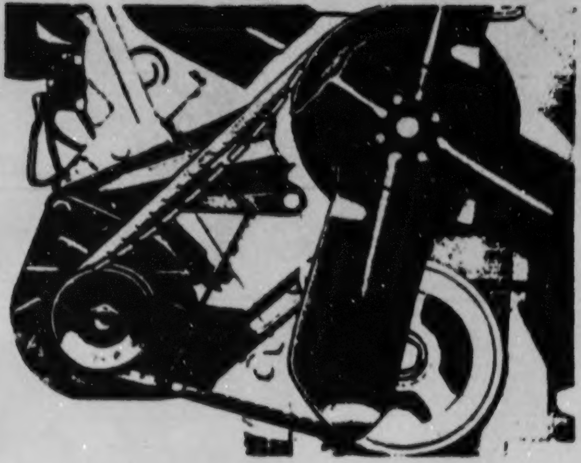


Figure 57. Adjusting Fan Belt Tension.

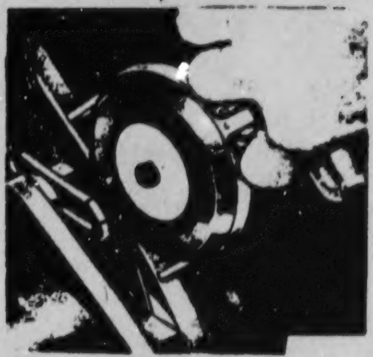


Figure 58. Checking Drive Belt Tension.

Finally, improper operation may result from a defective or improperly adjusted fan belt. If a fan belt is cracked, it may break during engine operation. If the sides of the belt are glazed or polished, it will slip in the pulley and not turn the cooling fan properly, the same as it would if the belt were too loose. On the other hand, if the belt is too tight it will wear out the bearings in the water pump and alternator. Correct belt tension can be achieved by measuring belt deflection as shown in figure 57. Always consult the manufacturer's manual for the exact amount of deflection. A special belt tension gage as illustrated in figure 58 is the best method to achieve proper belt tension.

Air Cooled Systems

In an air-cooled engine no liquid coolant is used. The engine is cooled by circulating air from a cooling fan and the air blast created from the movement of the vehicle. Baffles or air deflectors and a fan shroud are used to direct the airflow to the engine. The air cooled engine is also constructed differently than a liquid cooled engine. Each cylinder has fins on it and is bolted to the crankcase separately. Therefore, more surface area is exposed to the circulating air in the engine compartment. In addition to this, a small radiator called an oil cooler is used to help cool the engine's lubricating oil. The most important maintenance involved is to make sure the fan belt is good and properly adjusted, and that the engine is kept clean and free of foreign materials that would cut down on heat transfer to the air.

LUBRICATING SYSTEMS

The lubricating system of an engine is designed to supply oil to the moving parts of an engine so that these parts are not damaged by friction. This is accomplished by using a pump to circulate oil from the oil pan, to the various engine parts through drilled passageways in the engine.

The lubricating oil used in an engine serves several purposes. By occupying the small space between moving parts, oil keeps them from touching and allows them to slide over each other. This greatly reduces friction. Second, since motor oil is in direct contact with hot engine parts it absorbs heat and carries it back to the oil pan where cooling takes place as air flows over the pan. Third, a gas tight seal between the piston rings and cylinder wall would be impossible if it were not for the sealing action of oil. Finally, with the use of detergent oils, the engine can be kept clean internally. Motor oils are graded in four classifications which establish specific performance levels. The first level is recognized by the initials SD. This oil provides the greatest protection against high and low temperatures, corrosion, rust, and wear. The next lower grade is marked SC. Oils bearing this grade marking protect against the same things as SD oils, however, they do not protect as well. Oils marked as SB are for use in engines operated under mild conditions that need only the minimum protection. The last classification is designated as SA. This oil is not suited for use in automotive engines. Another characteristic of oils is how easily they pour. Some oils are quite thin and pour much like water, while other oils are much thicker and pour more like molasses. Oils are rated on this characteristic which is known as viscosity. For engines the viscosity rating normally ranges from 10W oils to 40W oils, 10W being the thinner. Some oils have a multiple viscosity rating such as 10W-30W. These oils are designed to cover a wide range of operating temperatures. The next item to consider is how the oil is circulated from the oil pan to the engine parts and back to the pan.

Oil travels from the oil pan to the intake side of an oil pump through an oil pick-up or strainer. A wire screen covers this inlet to keep out particles of carbon, metal or other foreign material. The oil is then pumped through an oil filter and into drilled passageways in the crankshaft to lubricate the main and connecting rod bearings. Oil passageways called galleries are also provided in the block to lubricate the camshaft bearing and valve

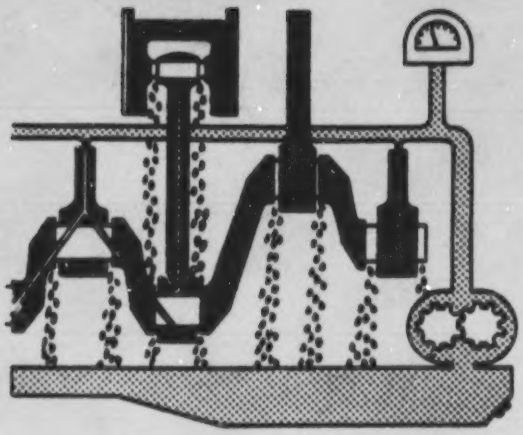


Figure 59. Full Force-Feed Lubrication System.

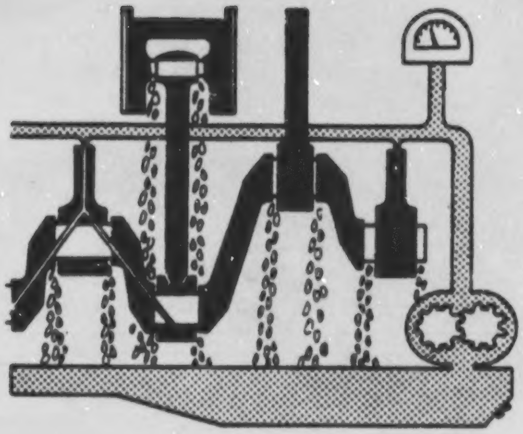


Figure 60. Force-Feed Lubrication System.

operating mechanism. The oil is then returned to the oil pan by means of drain-back holes in the engine. In addition to this, some engines have a hole drilled through the length of the connecting rod so that the piston pins can be lubricated under pressure. If such a hole is used, the system is termed full pressure or full force feed, if not it is called a force feed system. In either case the cylinder walls and piston are lubricated by oil thrown off of other moving parts or by splash and an oil spit hole in the crankshaft end of the connecting rod. These two oiling systems are illustrated in figures 59 and 60. The oil pumps used are either a gear type pump as shown in figure 61, or a rotor pump as shown in figure 62. Both types of pumps incorporate an oil pressure relief valve as shown in the illustrations. If the pressure in the lubricating system becomes higher than a predetermined specification, the spring loaded valve is forced off its seat and the excessive pressure is relieved by allowing some oil to by-pass the engine and be pumped directly back to the oil pan. By operating in this manner, the oil pressure relief valve controls the maximum pressure developed within the system. The oil filters

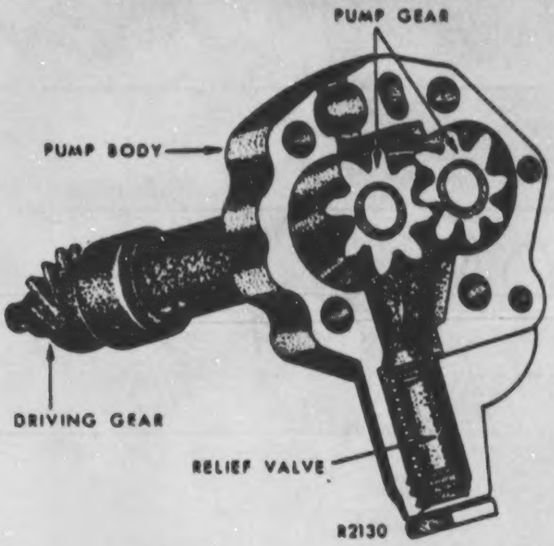

PUMP GEAR
PUMP BODY
DRIVING GEAR
RELIEF VALVE
R2130

Figure 61. Gear-Type Oil Pump.

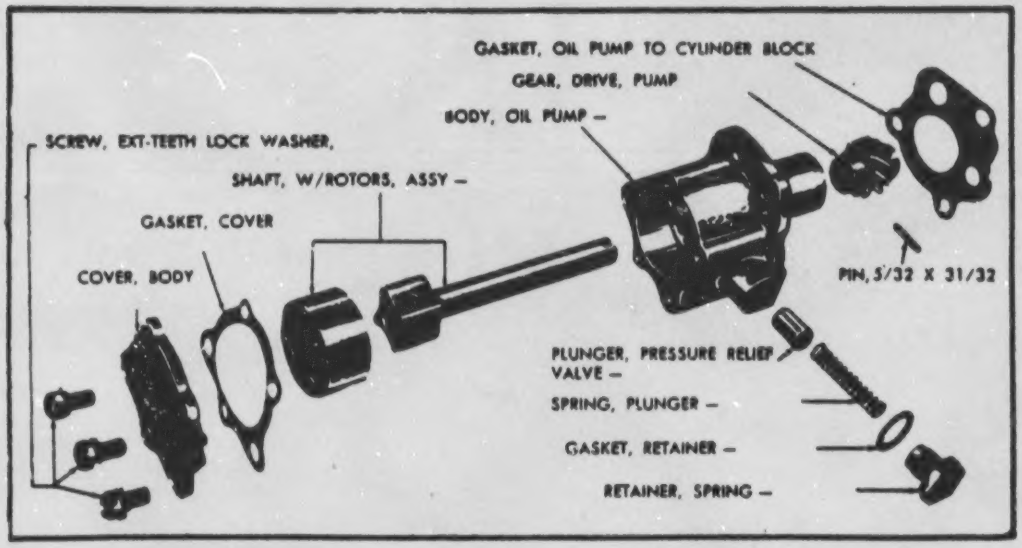

GASKET, OIL PUMP TO CYLINDER BLOCK
GEAR, DRIVE, PUMP
BODY, OIL PUMP –
SCREW, EXT-TEETH LOCK WASHER,
SHAFT, W/ROTORS, ASSY –
GASKET, COVER
COVER, BODY
PIN, 5/32 X 31/32
PLUNGER, PRESSURE RELIEF VALVE –
SPRING, PLUNGER –
GASKET, RETAINER –
RETAINER, SPRING –

Figure 62. Rotor-Type Oil Pump.

used on today's vehicles, filter all the oil from the pump before it goes to the engine. Therefore, if the filter becomes clogged, no oil would reach the engine. To compensate for this, a bypass valve is used in the filter. Then if the filter becomes clogged with dirt, the bypass valve is forced open by the oil from the pump and oil then goes directly to the engine without being filtered.

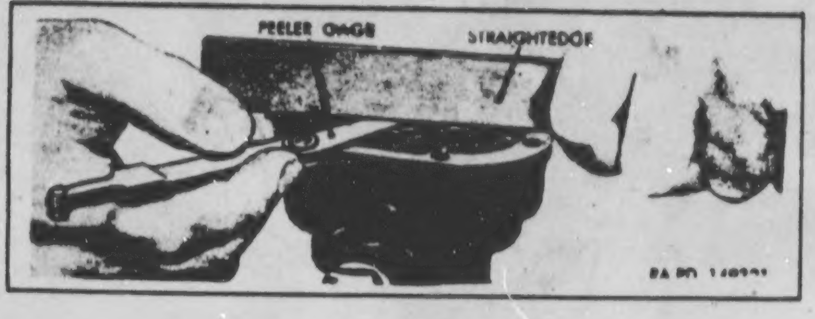

FEELER GAGE
STRAIGHTEDGE
RA PD

Figure 63. Check Gear to Cover Clearance.

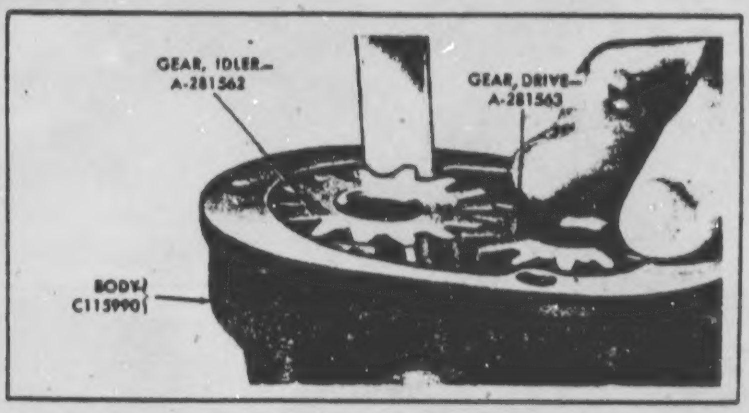

GEAR, IDLER—A-281562
GEAR, DRIVE—A-281563
BODY—C115990

Figure 64. Checking Gear to Body Clearance.

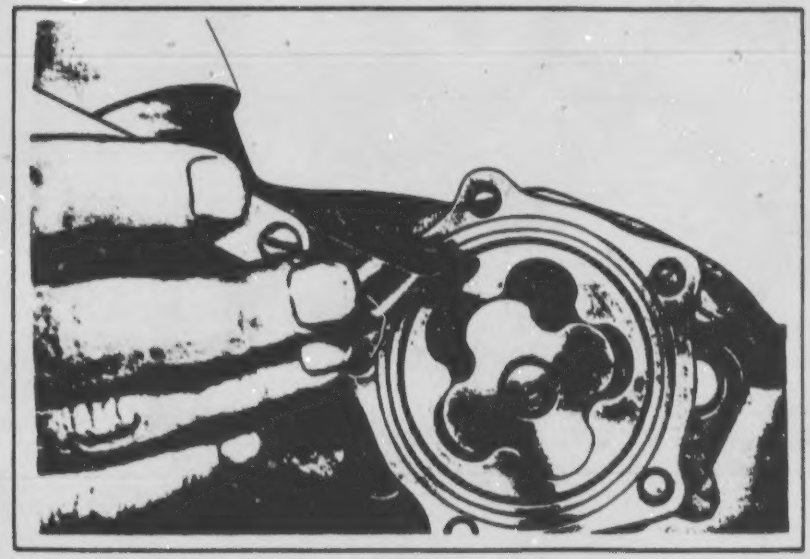


Figure 65. Checking Clearance Between Outer Rotor and Body.

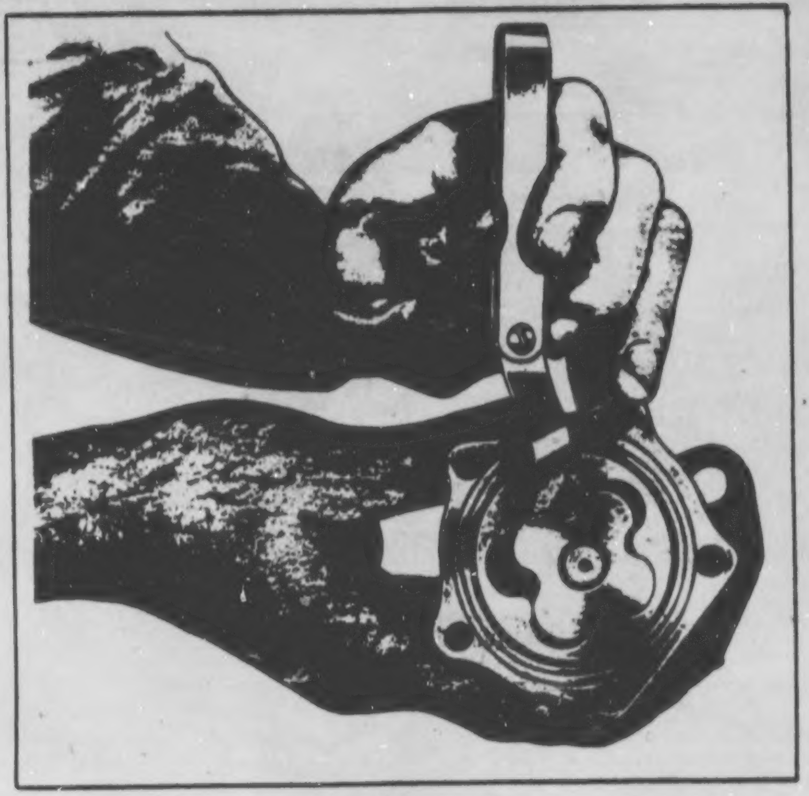


Figure 66. Measuring Clearance Between Rotor Lobes.

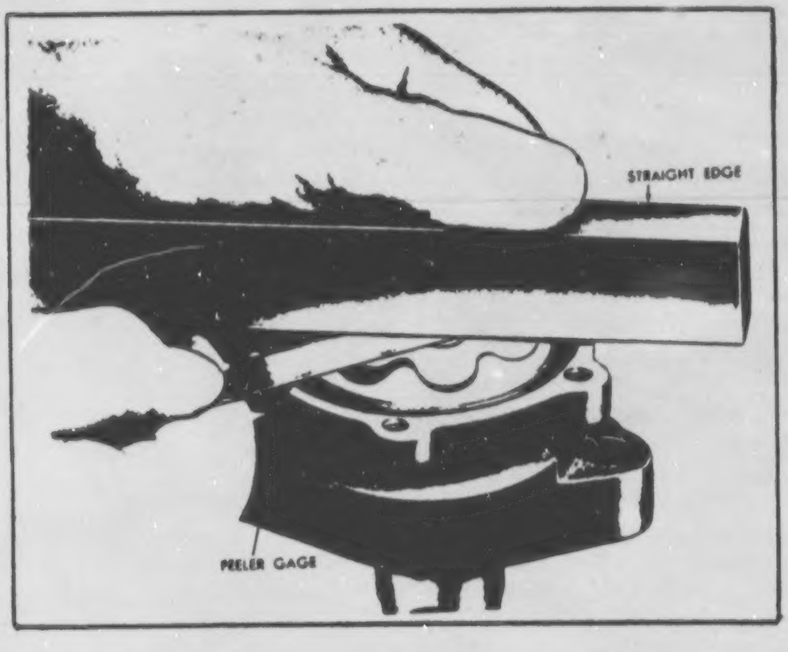

STRAIGHT EDGE
FEELER GAGE

Figure 67. Checking Inner and Outer Rotor Clearance to Cover.

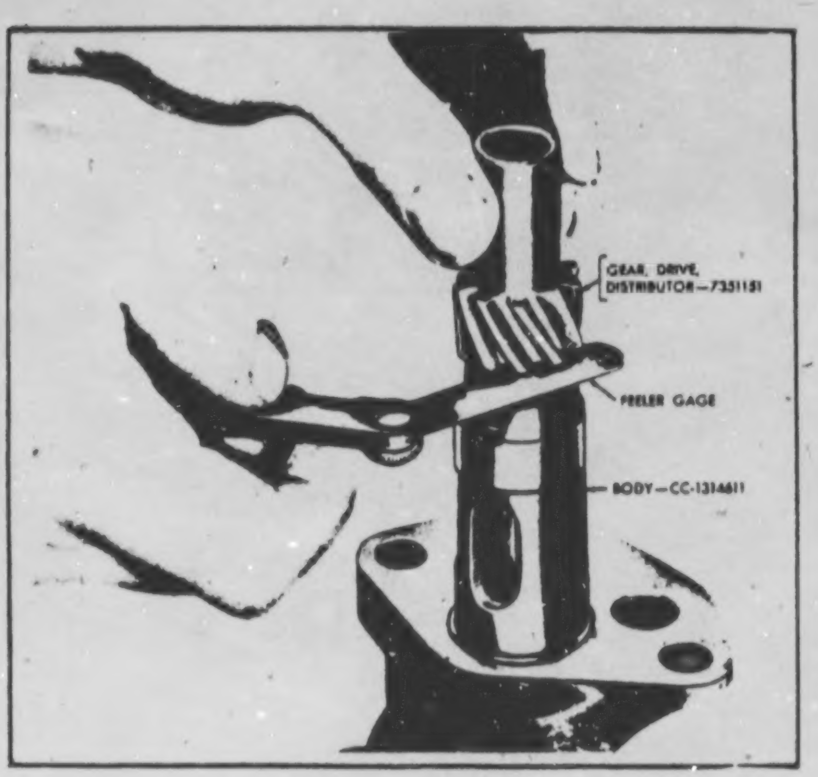


Figure 68. Checking Oil Pump Shaft End Play.

One problem that can occur in a lubricating system is a blocked oil gallery. If this does occur, the parts oiled from that passageway will fail. The damaged parts must then be replaced and the galleries cleaned to prevent further engine damage. Another malfunction is low oil pressure which will cause improper lubrication and premature engine failure. The problem here is to find out if the original malfunction was caused by a parts failure in the lubricating system or by some other problem. For example, if the fuel system supplies excessive amounts of gasoline to the engine's cylinders, much of the excess fuel will go past the piston rings and wash the oil off the cylinder walls. The excess fuel will then mix with the oil in the oil pan and thin it out. The results could be scored cylinder walls and damaged crankshaft and bearings. Another problem could result if the cooling system allowed the engine to run too hot. The excess heat would cause the oil to become too thin to maintain proper oil pressure and again, the engine would be damaged. Finally, if the oil isn't changed often enough it will become contaminated and not lubricate properly. This in turn will cause the engine bearings to wear excessively, and once the bearings are worn, low oil pressure will result. In this case however, low oil pressure wasn't the cause of the failure, just a symptomatic result. Within the lubricating system itself, low oil pressure could be caused by a lead oil pressure relief valve, ruptured gaskets in the oil pump, improper oil level in the crankcase, improper clearances within the working parts of the pump, or a sheared pin on the oil pump drive gear. (Refer to figure 62.) Figures 63 thru 68 illustrate the checks made on the working clearances of a gear and rotor type pump.

CRANKCASE VENTILATION

More recently this subject may be referred to as control of crankcase emissions. The following operating characteristics of engines have made this system necessary: (1) during warmup periods when the carburetors choke is in use, excess fuel will get past the piston rings and dilute the oil, (2) condensation of water in the crankcase mixes with sulphur compounds in engine oils and causes the formation of sulphuric acid, (3) blow-by of combustion gasses during engine operation causes sludge formation and oil dilution. These foreign materials exist in the form of vapors when the engine oil is at normal operating temperature, and it is the job of the crankcase ventilating system to remove them from the engine.

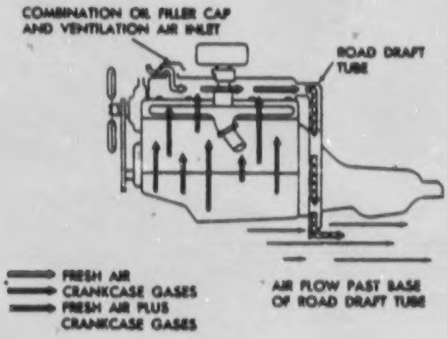

COMBINATION OIL FILLER CAP AND VENTILATION AIR INLET
ROAD DRAFT TUBE
FRESH AIR
CRANKCASE GASES
FRESH AIR PLUS CRANKCASE GASES
AIR FLOW PAST BASE OF ROAD DRAFT TUBE

Figure 69. Road Draft Tube System.

Non-Positive or Draft Tube Ventilation

Most vehicles built before 1963 used this system. On this set-up a vent or draft tube was installed in the engine above the oil level of the crankcase. When the vehicle was in motion, air rushing past the open end of the tube created a partial vacuum that pulled fresh air into the engine through the oil filler cap, engine and out the draft tube. The low pressure air stream caused crankcase vapors to rise from the oil pan, enter the air stream and be discharged through the draft tube. (Refer to figure 69.)

Positive Crankcase Ventilation (Open Type)

On this system the draft tube was replaced with a hose connected to the intake manifold. This manifold vacuum was used to cause air circulation through the engine, and the crankcase. Vapors are carried into the combustion chambers by way of the intake manifold and burned with the fuel mixture. A valve called the P.C.V. valve is used to control the amount of crankcase vapors entering the combustion chambers so that the air-fuel ratio isn't upset.

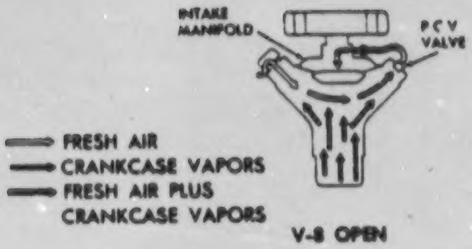

INTAKE MANIFOLD
PCV VALVE
FRESH AIR
CRANKCASE VAPORS
FRESH AIR PLUS CRANKCASE VAPORS
V-8 OPEN

Figure 70. Open System.

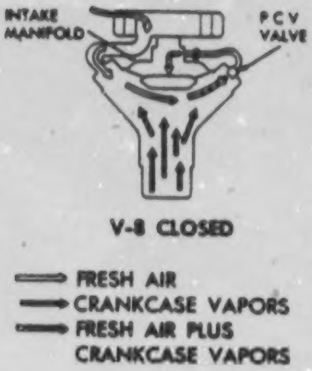

INTAKE MANIFOLD
PCV VALVE
V-8 CLOSED
FRESH AIR
CRANKCASE VAPORS
FRESH AIR PLUS CRANKCASE VAPORS

Figure 71. Closed System.

Positive Crankcase Ventilation (Closed Type)

After 1968, all production cars used the closed system. This set-up is the same as the open system with the exception of the air inlet. Instead of air entering the engine through the oil filler cap, it enters on the clean air side of the carburetor air filter and is piped into the engine as shown in figure 71. The advantage of the closed system is apparent if there is ever a build up of crankcase pressure. In the open system blow-by gasses could be forced into the atmosphere through the oil filler cap. However, in the closed system blow-by gasses would be forced into the air cleaner, mixed with the air fuel mixture and burned, not discharged into the air.

VALVE RECONDITIONING EQUIPMENT

Due to the many varying types of valve reconditioning equipment, the use of the particular equipment on hand will be taught by your instructor and the applicable technical publication.

SUMMARY

This chapter has dealt with cooling, lubricating, and crankcase ventilating systems. As a special point of review note the interrelationships of the various systems and how a malfunction in one system can cause trouble in another different system.

QUESTIONS

1. What is the purpose of a cooling system?

2. When inspecting a liquid cooling system, what do you look for?

3. How does the pressure radiator cap work and what does it do?

4. Explain the differences in operation of a liquid and an air cooling system.

5. List five specific liquid cooling system malfunctions and explain how they are corrected.

6. List the purposes of the lubricating system.

7. Explain how a lubricating system works.

8. What are some causes of low oil pressure? (At least three.)

9. What is the difference between oil viscosity ratings and service classifications?

10. Explain how cooling and lubricating systems can affect each other.

11. What is the purpose of a crankcase ventilating system?

12. Explain the differences between the three types of crankcase ventilating systems.

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-SG-206

GASOLINE ENGINE FUEL SYSTEM UNITS

OBJECTIVES

At the conclusion of this lesson you will be able to explain the operation, function, and relationship of gasoline fuel-air system components.

INTRODUCTION

The purpose of the fuel system is to supply a proper mixture of air and fuel to the vehicle's engine for all ranges of engine operation. This chapter will deal with the fuel tank, lines, filter, and pump. The carburetor will be discussed in a separate chapter due to its complexity. The subject of electric fuel pumps will not be included because of their extremely limited use on general purpose vehicles.

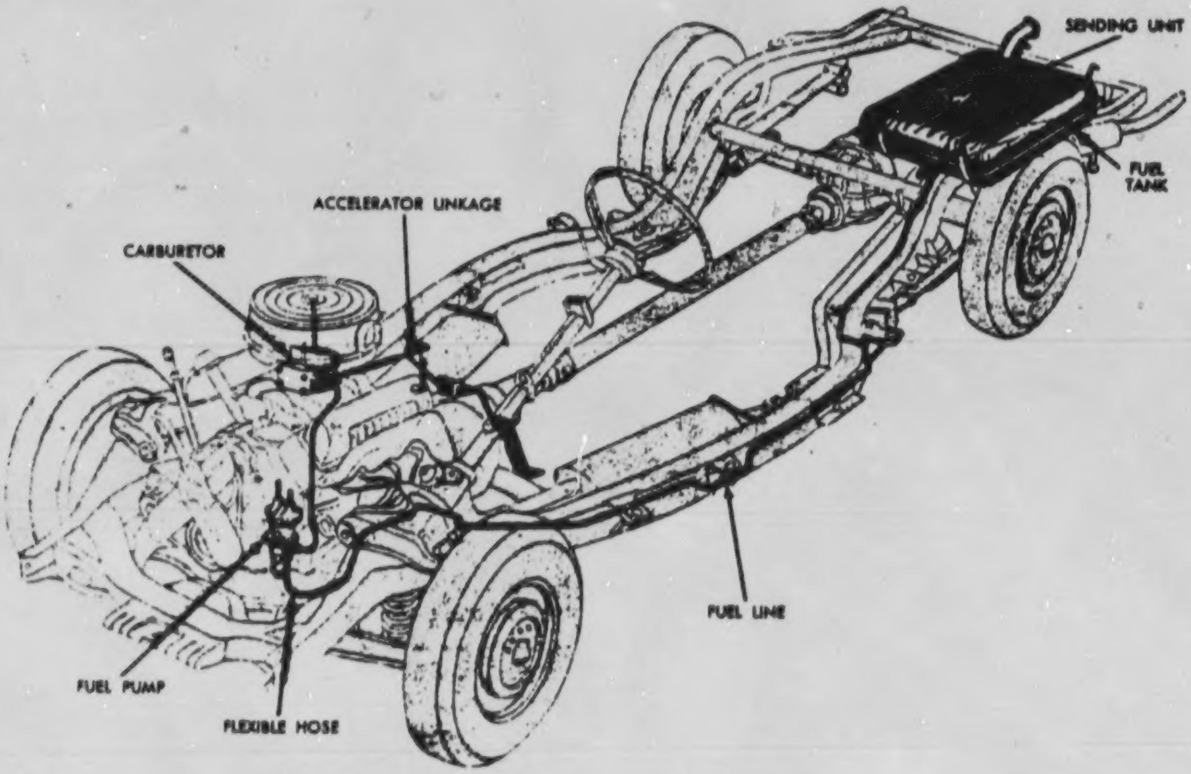

SENDING UNIT
FUEL TANK
ACCELERATOR LINKAGE
CARBURETOR
FUEL LINE
FUEL PUMP
FLEXIBLE HOSE

Figure 72. Typical Gasoline Fuel System.

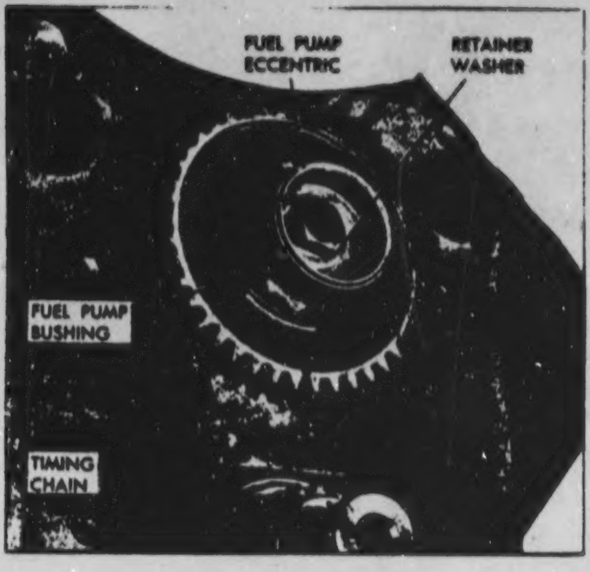


Figure 73. Front of Engine with Timing Chain Cover Removed.

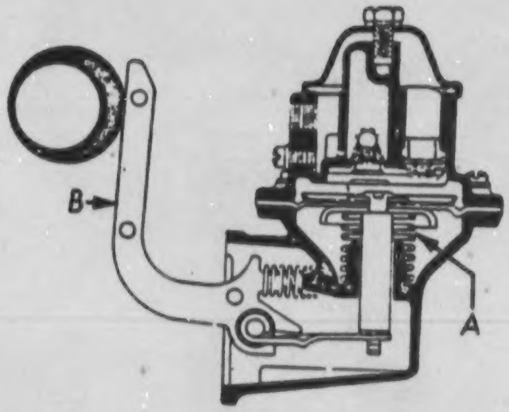


Figure 74. Fuel Pump.

INFORMATION

OPERATION

A common gasoline engine fuel system is pictured in figure 72. The fuel pump is driven by the eccentric lobe of the engines camshaft or by an eccentric bolted to the camshaft gear as shown in figure 73. Figures 74 and 75 illustrate a mechanically operated diaphram type pump in common use today. As the pump is operated by the fuel pump eccentric a flexible diaphram alternately produces a partial vacuum and then pressure inside the pump.

On the vacuum or intake stroke the camshaft eccentric pushes against the fuel pump rocker arm, figure 74(B), and the rocker

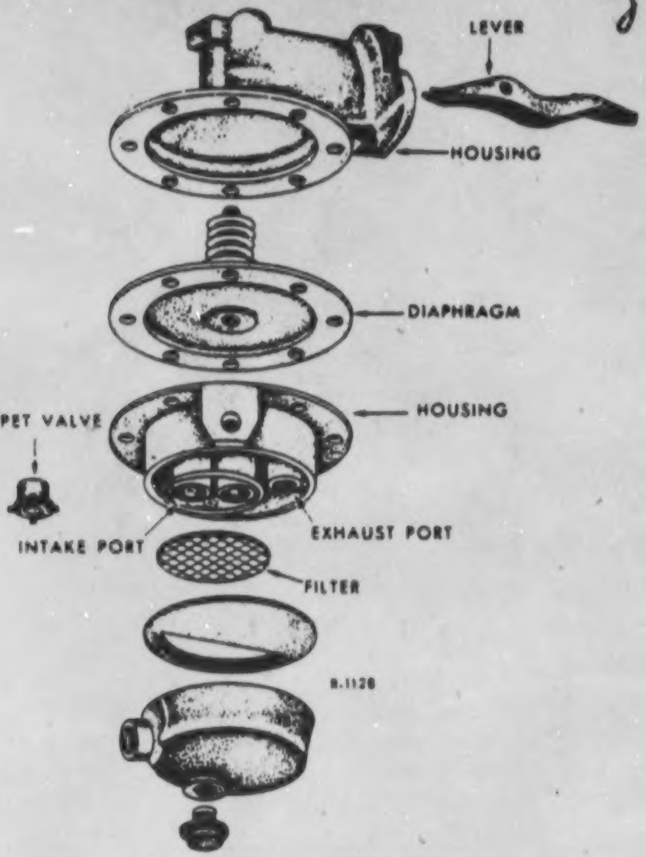


Figure 75. Fuel Pump - Exploded View.

arm pulls down the flexible diaphragm and compresses the diaphragm spring, figure 74(A). The downward movement of the diaphragm creates a low pressure area inside the pump. Atmospheric pressure enters a vent in the fuel tank and forces fuel into the low pressure area inside the pump. As the camshaft eccentric rotates further it releases the pressure on the rocker arm and the diaphragm spring expands forcing fuel to the carburetor. This is the discharge stroke. A one way flow of fuel is maintained through the pump by means of two poppet valves, figure 75. When the carburetor has a sufficient supply of fuel, a valve (which will be discussed later) closes and shuts off the fuel from the discharge side of the pump. The fuel pump rocker arm will continue to be operated by the camshaft eccentric, but the pressure created by the fuel trapped in the closed line will keep the diaphragm from moving. Therefore no more fuel will be delivered to the carburetor until the valve opens and allows fuel to enter the carburetor again.

A pump that operates in this manner is called a non-positive pump. On vehicles equipped with air-conditioning or those that have high temperatures under the hood, the above fuel system causes a problem. When the engine is shut off, the temperature in the engine compartment rises. This causes the gasoline trapped in the fuel line between the pump and carburetor to expand and force

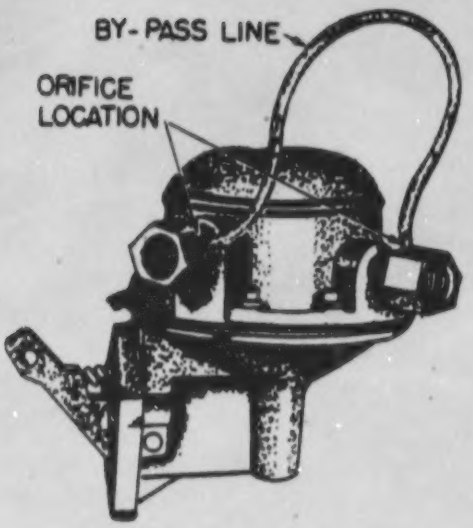


Figure 76. Fuel Lines.

its way past the closed carburetor valve. As a result the carburetor floods and the engine is hard to start when hot. To correct this problem a by-pass line is installed somewhere between the discharge side of the fuel pump and the carburetor, the other end of the line goes to the intake side of the pump or back to the fuel tank. A small opening called an orifice controls the amount of fuel that flows through this by-pass. This orifice is small enough so that fuel pump operation will not be affected during normal engine operation, however, when the engine is shut off, pressure from the discharge side of the fuel pump is relieved. The results are that engines start easier when they are hot due to less flooding and reduced vapor locks (gasoline boiling in the lines). Refer to figure 76.

Fuel Lines

The fuel line from the tank to the engine compartment is usually lead-coated steel. Steel line is necessary due to the vibrations and rocks that are likely to hit a fuel line located underneath the vehicle. A flexible hose (usually neoprene) connects the line mentioned above to the fuel pump. This flexible line allows for the movement of the engine on its mounts. If a rigid line was used at this point it would soon break from constant flexing action. From the fuel pump to the carburetor, either type of line may be used, however the steel line is preferred.

Fuel Gauges

There are two basic types of fuel gauges, the "balancing coil" and the "thermostatic." Each type uses a sending unit in the tank and a dash unit, figures 77 and 78.

333

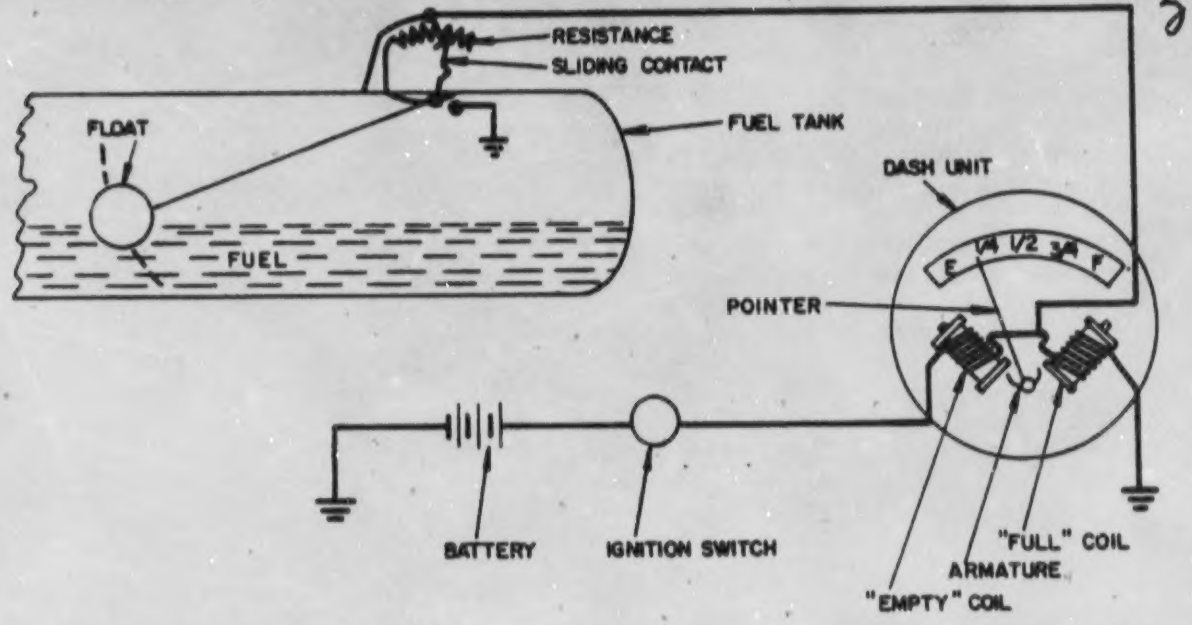

RESISTANCE
SLIDING CONTACT
FLOAT
FUEL TANK
DASH UNIT
FUEL
E
1/4
1/2
3/4
F
POINTER
BATTERY
IGNITION SWITCH
"FULL" COIL
ARMATURE
"EMPTY" COIL

Figure 77. Schematic Wiring Circuit of Balancing Coil Fuel Gauge.

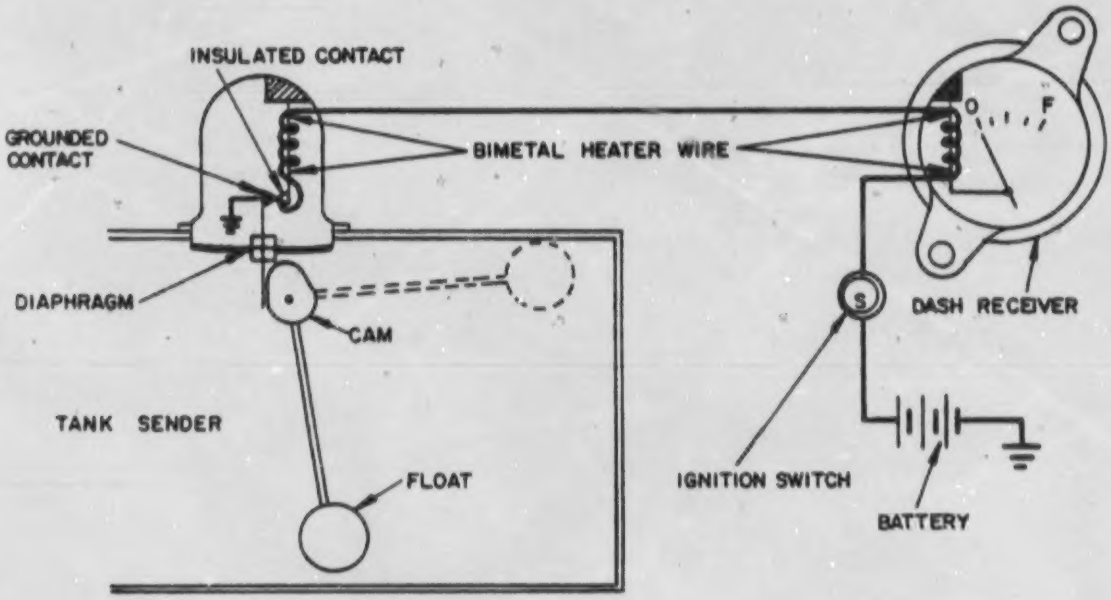

INSULATED CONTACT
GROUNDED CONTACT
BIMETAL HEATER WIRE
O
F
DIAPHRAGM
CAM
S
DASH RECEIVER
TANK SENDER
FLOAT
IGNITION SWITCH
BATTERY

Figure 78. Bimetal-Thermostat Type Fuel Gauge (Tank Empty).

The tank unit of the balancing coil type has a sliding contact that slides back and forth on a resistance strip as the float moves up and down in the fuel tank. This will change the amount of electrical resistance the tank unit offers. As the tank empties, the float drags and the sliding contact moves to reduce the resistance. The dash unit contains two coils. When the ignition switch is turned on, current flows through the two coils producing a magnet that acts on a pointer. When resistance in the tank unit is high (tank illed), the current flowing through the "empty" coil also flows through the "full" coil. When this occurs the pointer is pulled to the right so that the pointer indicates FULL. When the tank begins to empty, the resistance of the tank unit drags. Thus, more of the current that would have gone through the full coil, now flows through the tank unit and the "empty" coil pulls the needle forward to EMPTY. Some units of this type use only one coil balanced against a spring hooked to the pointer.

The thermostatic gauge has a pair of bi-metal strips that bend when they are heated. Each strip is wrapped with a heater wire connected to the battery through the ignition switch. These coils carry the same amount of current and heat both bi-metal strips the same amount. When the tank is full, the cam moves a contact button and distorts the tank unit bi-metal strip. Therefore, the blade must heat considerably before it bends enough to move away from the contact button. While this blade is heating, the blade in the dash unit is also heating and the pointer is pulled toward FULL. After the tank blade heats enough to break the electrical circuit it cools and moves back to the contact button, thus a vibrating action takes place. As the tank empties, less heating is required to keep the tank unit at the vibrating point due to less pressure applied to the contacts by the cam. Therefore the dash unit heats less, the blade bends less and the pointer moves toward EMPTY.

MALFUNCTION AND REPAIR

The fuel tank, tank mounts, and lines will deteriorate from corrosion and rocks thrown from the vehicle's tires. When this happens, the defective units should be replaced. If a new fuel tank is unavailable the old one can be brazed or welded. However, if this action is taken, it must be done in accordance with existing safety regulations and procedures. Another cause of fuel tank failure is a plugged vent or improper tank cap. In either case, the tank will be subject to a vacuum build up and will collapse. The fuel filter should be changed at time intervals specified by the manufacturer. If it becomes clogged before it is due to be changed, replace it and inspect the rest of the system for excess deposits of dirt or debris. Should the pump become defective it must also be replaced. Fuel pumps on new vehicles are not repairable, see figure 79. For older vehicles which have repairable pumps, a repair kit is seldom available so they too must be replaced.

To determine fuel pump serviceability three tests are performed: (1) a volume test on the carburetor side of the pump,

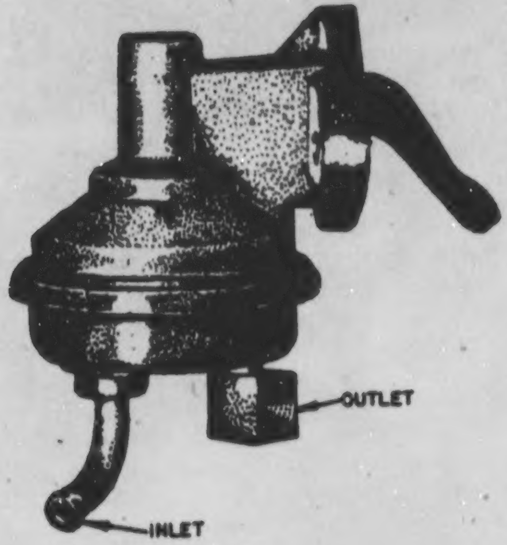


Figure 79. Fuel Pump (Non-Serviceable).

(2) a pressure test on the carburetor side of the pump, and (3) a vacuum test on the tank side of the pump. The volume test is performed by inserting the discharge fuel line from the pump into a pint measuring bottle. The engine is operated at idle speed and on the average, it should take 20 to 30 seconds to fill the container. (Check manufacturer's specifications.) Insufficient volume is usually caused by a pinched fuel line, worn cam-shaft eccentric or fuel pump rocker arm, dirty fuel filter, or air leaks on the intake side of the pump. To test for air leaks a vacuum test is performed on the intake side of the system, first at the pump and then at the fuel line where it enters the tank. Use a vacuum gauge and operate the engine according to the manufacturer's test procedures. If the reading at the pump is low then the pump is defective. If the pump reading is alright but the reading at the tank is low, then there is an air leak between the tank and the pump. Check the lines for holes, loose connections, poor hose clamps and so on. The final test is the pressure test. The fuel line is removed at the carburetor and connected to a pressure gauge. The engine is operated according to the manufacturer's testing instructions and the pressure noted. If the pressure is low the cause could be as follows: (1) worn camshaft eccentric or fuel pump rocker arm, (2) hole in the diaphragm accompanied by gasoline spurting from the fuel pump vent hole or large amounts of fuel in the crankcase, or (3) dirty or gummy check valves from using a poor grade of gasoline. When the engine is shut off the gauge should still indicate pressure in the line unless: (1) the intake and discharge check valves leak or (2), the fuel system is the by-pass type previously described. Low pressure could also be caused by a weak diaphram spring. If the pressure is too high then look for the following: (1) a tight diaphragm (2) fuel between the layers of the diaphragm material, (3) diaphragm spring too strong, or (4) fuel pump link frozen to the rocker arm. To troubleshoot fuel system gauges and sending units it will be necessary to refer to the

specific manual of the vehicle in question, due to the differences in electrical systems among various manufacturers.

EVAPORATIVE EMISSION CONTROL SYSTEMS

As previously mentioned, the fuel tank is vented in order for atmospheric pressure to enter the system and push fuel from the tank to the fuel pump. This vent also allows for expansion of the fuel when the tank and its contents get warm. Before 1971, (except in California), this venting was accomplished by means of an open pipe in the fuel tank, or by means of a vented gas cap. However, this method of venting fuel tanks allowed raw fuel and fumes to escape into the air and increase pollution. Therefore, a closed venting system is now required on all vehicles. In this system a pressure/vacuum relief gas cap is used to protect the fuel tank from excess pressure differentials. The fuel vapors are now vented into the vehicle's P.C.V. system and burned in the engine's combustion chambers. The overflow of liquid fuel caused by heat during summer operation is either trapped in an expansion tank or taken care of by some form of liquid vapor separator and then returned to the fuel tank. The various methods used to accomplish the above will be studied in greater detail in a later block of instruction.

SUMMARY

This chapter has covered the purpose, operation, malfunctions and repair of fuel system components excluding carburetors. It has also covered the basic function of the closed venting system used to control evaporative emissions. The malfunctions that can develop in a fuel system are many and varied. Sometimes a combination of two or more problems may exist at the same time. Therefore, it is important to check and isolate any malfunctions by logical means; proven test procedures recommended by the manufacturer. Use the book and do not depend on memory, it will save time in the long run.

QUESTIONS

1. What are the three fuel pump tests?

2. Describe the basic procedures used to perform these tests.

3. For each test, list some of the possible results and what they mean.

4. Describe how the fuel system supplies fuel from the tank to the carburetor.

5. In an evaporative emission control fuel system, what protects the fuel tank from excess pressure or vacuum?

337

CONSTRUCTION AND OPERATING PRINCIPLES OF CARBURETORS AND GOVERNORS

OBJECTIVES

After completing this unit of instruction you will be able to explain the principles of operation, function, and relationship of gasoline engine fuel-air system components.

INTRODUCTION

The purpose of a carburetor is to supply a proper air fuel mixture for all ranges of engine operation. A mixture that is too rich may damage the engine by thinning the oil. A lean mixture results in loss of power and possible engine damage through excessive heat.

INFORMATION

An air fuel mixture or ratio is expressed by two numbers such as 15 to 1. The first number refers to the amount of air, the second to fuel. Therefore, a mixture of 15 to 1 means 15 parts of air to one part of fuel, and the measure is by weight. A mixture with more air for the 1 part of fuel (such as 18 to 1) would be leaner than 15 to 1, and a mixture with less air (12 to 1) would be richer than 15 to 1. Air fuel ratios have received a lot of attention recently in connection with exhaust emission controls designed to reduce air pollution. The pollutants in automobile exhausts include many different types of chemicals that are divided into three basic chemical groups. These are: (1) hydrocarbons or (HC), the basic compounds of gasolines, (2) carbon monoxide or (CO), which is a deadly gas resulting from the burning of fuel, and (3) nitric oxides (NOx) or lead compounds. Much of this pollution is caused by incomplete combustion of the air-fuel mixture. In order to correct these problems, automobile manufacturers have, and are continuing to develop different systems to control air pollution. The study of these individual systems will be accomplished later in this course, however, one thing should be noted now; air-fuel ratios are leaner now than they were in previous years. The reason for this is that leaner mixtures burn cleaner and thereby reduce pollution. Some general examples will illustrate the differences in the air-fuel ratios of newer versus older vehicles (note following examples). These figures are general ranges only.

Range of Operation	Old A/F Ratio	New A/F Ratios
Idle Speed	12.3 to 1	14.4 to 1 or leaner
Lo peed Cruising	13.5 to 1	14.4 to 1 or leaner
Hi Speed Cruising	15 to 1	16 to 1 or leaner

In previous years, the test equipment used to adjust and troubleshoot fuel-air systems measured the air-fuel ratio. This test

357

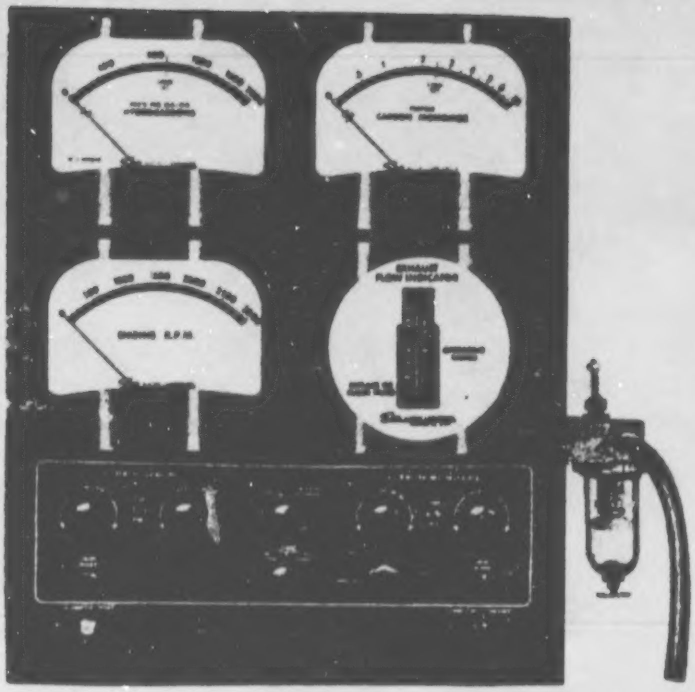


Figure 80. Test Equipment for Measuring Amounts of Hydrocarbon and Carbon Monoxide.

equipment did not have the capability of actually measuring the pollutants present in exhaust gasses. Through increased technology and stricter federal laws, test equipment has been developed to directly measure the amount of hydrocarbons and carbon monoxide present in exhaust gasses. One such tester is illustrated in figure 80. This type of equipment will be necessary in order to meet new federal requirements and will replace A/F ratio gauges for the purposes of tune-up and troubleshooting A/F systems. The federal laws in 1968 set pollution standards at 275 parts per million for (275 parts hydrocarbon to 1,000,000 parts of exhaust gas) hydrocarbons and 1.5 percent for carbon monoxide. In 1970 they were changed to a grams per mile basis and limited to 2.2 grams per mile for hydrocarbons and 23 grams per mile for carbon monoxide. The 1975 standards will require even more effective control of HC, CO, and will also include control of NOx.

THE BASIC FACTS AND PRINCIPLES OF CARBURETION

As a Matter of Fact

The carburetor must supply the engine with the correct mixture of fuel and air to insure good combustion. Because mixture requirements vary with temperature, speed and load on the engine, it is very difficult to provide perfect carburetion for all operating conditions, figure 81.

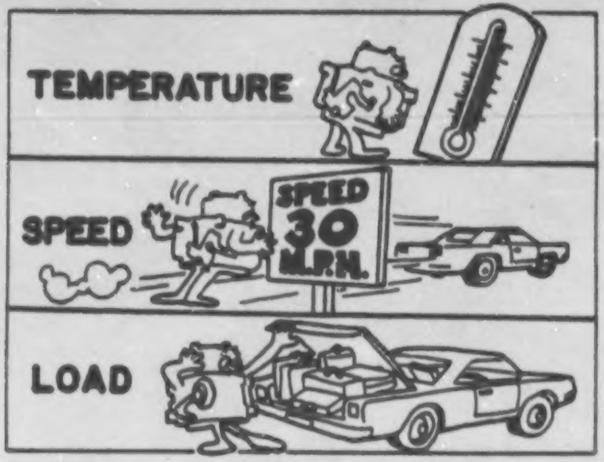


Figure 81. Operating Conditions Affect Mixture Requirements.

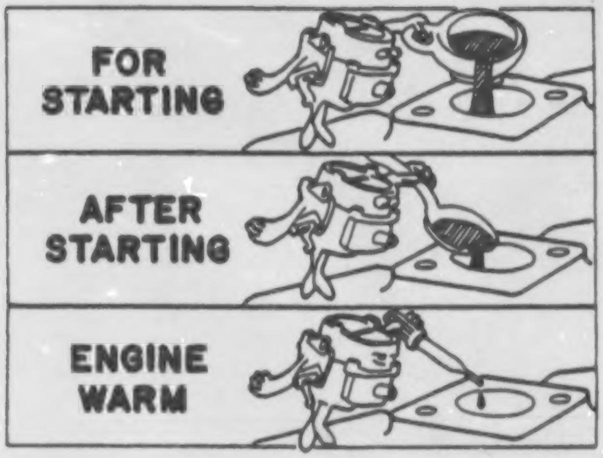


Figure 82. Mixture Requirements Change with Temperature.

MIXTURE NEEDS CHANGE WITH TEMPERATURE. Outside temperature as well as engine operating temperature affects air-fuel ratio requirements. For ease of starting, particularly in cold weather, a very rich mixture is needed. The instant the engine starts, the air-fuel ratio requirement changes. The proportion of air to fuel must be increased to prevent flooding and stalling. As the engine warms up, fuel vaporization improves and progressively leaner mixtures are called for, figure 82.

MEETING SPEED AND POWER REQUIREMENTS. Changes in engine speed and power output also affect air-fuel ratio requirements. At idle and during low-speed, low-power operation, a lean mixture is required to minimize exhaust emissions. At medium speed and part-throttle, still leaner mixtures must be supplied for good

340

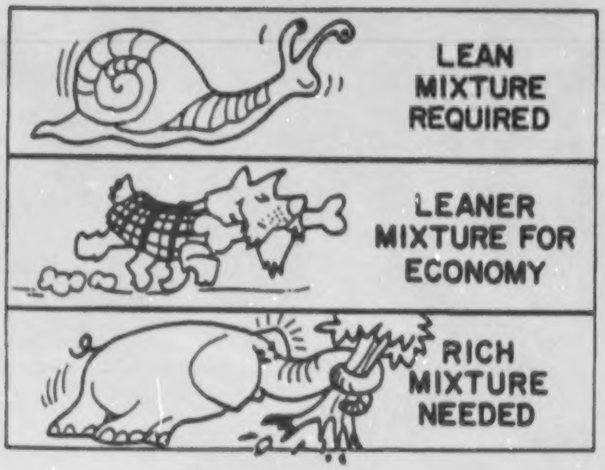

LEAN MIXTURE REQUIRED
LEANER MIXTURE FOR ECONOMY
RICH MIXTURE NEEDED

Figure 83. Speed and Power Affect Mixture Needs.

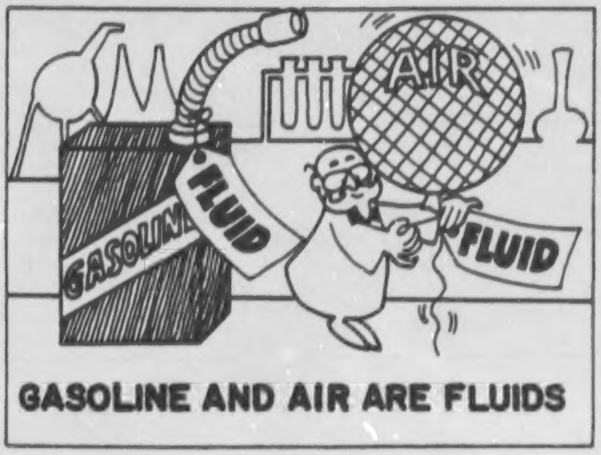

AIR
GASOLINE
FLUID
FLUID
GASOLINE AND AIR ARE FLUIDS

Figure 84. If it Flows, it can be Classified as a Fluid.

fuel economy. For maximum power, a rich mixture is needed. It's a fact that the engine uses about thirty or forty times as much air to produce maximum power as it does when the engine is idling. This will give you some idea of how versatile the carburetor must be and how difficult a job it is to provide the correct air-fuel ratio for all operating conditions, figure 83.

IF IT FLOWS IT'S A FLUID. The entire science of carburetion is concerned with the flow of fuel and air. Scientifically speaking, both gasoline and air are classified as fluids because they can be made to move or flow. For example, water is a fluid and it flows readily through a garden hose. Since air can be made to flow through a hose, it is also a fluid, figure 84.

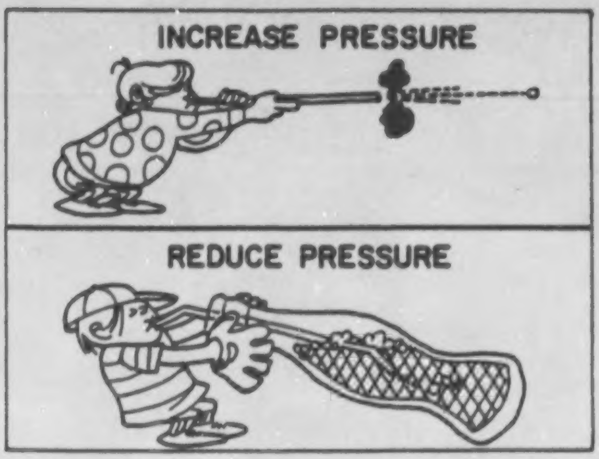


Figure 85. A Difference in Pressure Causes Fluids to Flow.

WHAT MAKES FLUID FLOW? The flow of any fluid, either a gas or a liquid, is the direct result of a difference in pressure. The direction of flow is always away from the higher pressure and towards the lower pressure. It doesn't matter whether the difference in pressure is created by increasing the pressure at one end or reducing the pressure at the other end. In other words, you can move a fluid, gas or liquid, by increasing pressure at one end and blowing it through a tube, or you can make it flow by reducing the pressure at one end of a tube. Scientifically speaking, the "suction" that pulls a soda through a straw is actually a lowering of the pressure at the mouth-end so that the higher atmospheric pressure acting on the delectable concoction can push it up the straw and into the sipper's mouth. In the case of either a bean shooter or a soda straw, it's the pressure difference that moves the fluid. Now, let's see why it is important to understand this principle as it applies to carburetion, figure 85.

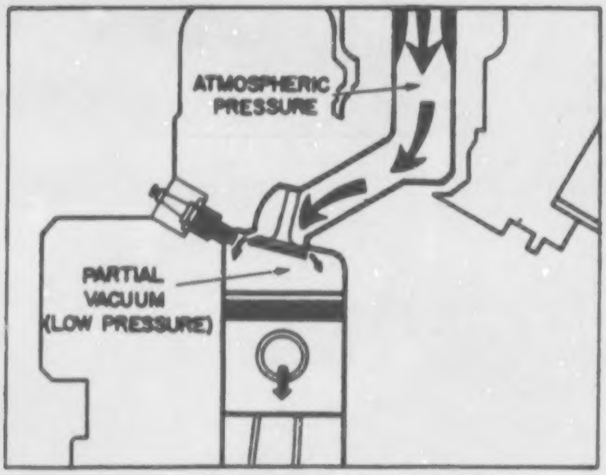


Figure 86. The Engine Is Also a Vacuum Pump.

AN ENGINE IS ALSO A PUMP. The engine's primary job is to produce power, but on the intake stroke it is a very efficient vacuum pump. The downward movement of the piston creates a partial vacuum or low pressure condition in the cylinder. The higher atmospheric pressure pushes air through the carburetor, through intake manifold and into the cylinder, as shown in figure 86.

This is a Matter of Principle

The venturi is one of the most important devices used in the carburetor. It is simply an hourglass-shaped reduction in the size of a tube or passage. But let's see what a venturi does to air flow and how it affects pressure.

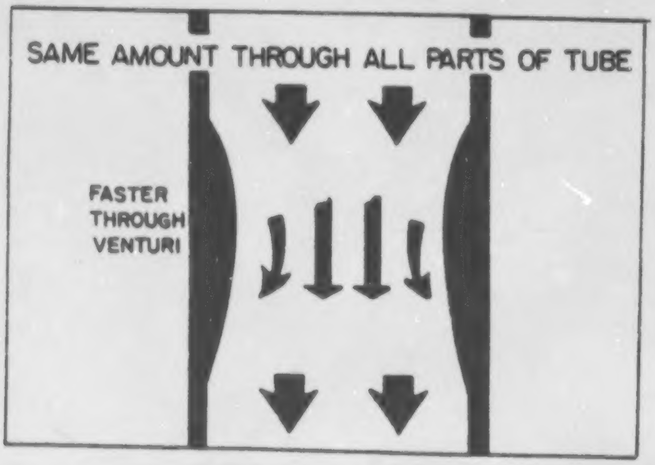


Figure 87. Air Flows Faster through the Venturi.

IT'S HURRY! HURRY! HURRY! Since the same amount of air flows through all parts of a tube, it has to speed up and flow faster through the narrowest part. For example, if the cross-sectional area of the venturi is only half as large as the rest of the tube, the air will go twice as fast through the venturi, as shown in figure 87.

SPEED GOES UP AND PRESSURE GOES DOWN. As the velocity of the air flowing through the venturi increases, the pressure decreases. The velocity of the air is greatest and the pressure is the lowest at the narrowest section of the venturi. A scientific, fluid dynamic explanation of why a venturi causes a pressure drop is a bit complex. However, there is a simple everyday example of how increasing the speed of air flow results in a reduction in pressure, figure 88.

DON'T LET THE VENTURI ACTION BUG YOU. Just about everyone has used a hand-operated bug sprayer at one time or another. And you know that pumping air across the nozzle-end of the pickup tube pulls fluid out of the tank and squirts it at the plant or the bugs thereon. The reason the fluid flows up the tube is because the pressure at the nozzle-end of the tube is lower than the pressure at the lower end of the tube.

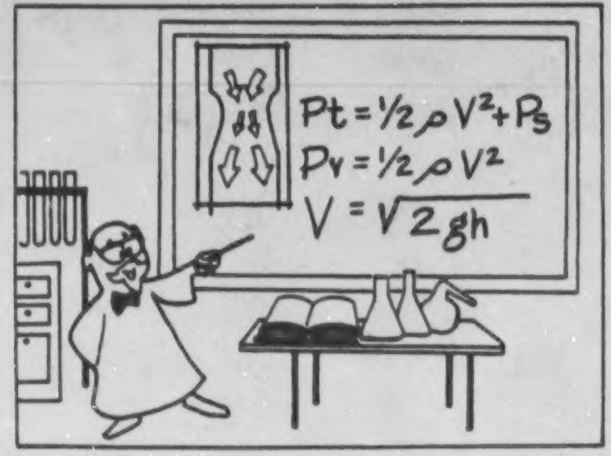

$Pt = 1/2 \rho V^2 + P_s$
$P_v = 1/2 \rho V^2$
$V = \sqrt{2gh}$

Figure 88. Formulas Explaining Venturi Action.

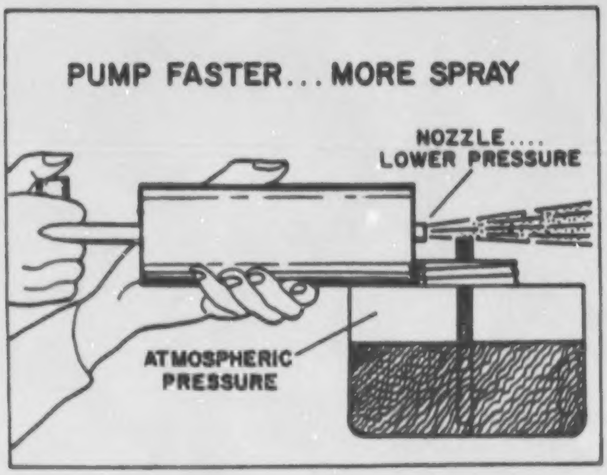

PUMP FASTER... MORE SPRAY
NOZZLE.... LOWER PRESSURE
ATMOSPHERIC PRESSURE

Figure 89. Increasing Air Flow Lowers the Pressure.

You also know that pumping the bug sprayer faster increases the amount of spray that comes out of the nozzle-end of the tube. That's because increasing the speed of the air flowing past the pickup tube lowers the pressure at the top of the tube even more, so there is still greater pressure difference between the top and the bottom of the pickup tube. In a carburetor, a venturi is used to increase the speed of the air and lower the pressure at the throat of the venturi, figure 89.

THE FLOAT AND LOW-SPEED SYSTEMS

The Float and the Throttle Valve

So far we have covered the basic factors affecting an internal combustion engine's fuel mixture requirements. We have also discussed the principle of fluid flow and the function of a venturi. Next, we will explain how these fundamentals apply to as simple carburetor.

THE FLOAT CONTROLS THE NEEDLE VALVE. The fuel pump takes gasoline from the fuel tank and delivers it to the inlet of the fuel bowl at a constant pressure....regardless of engine speed. The float controls the needle valve, which in turn, controls the flow of gasoline so that the fuel in the bowl is always maintained at the same level.

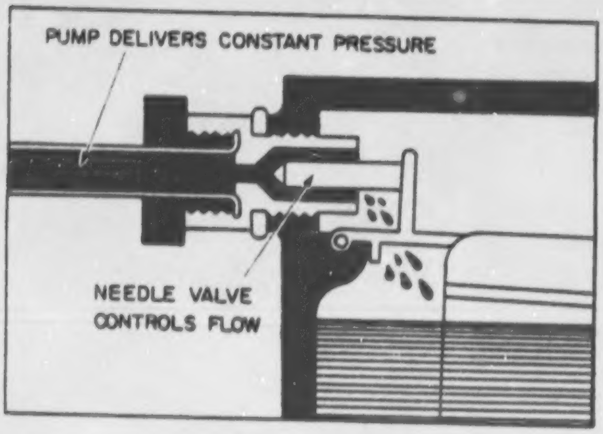


Figure 90. The Float Controls the Needle Valve.

The slightest drop in the level of the fuel in the fuel bowl allows the float to drop and this opens the needle valve. As soon as the level of fuel in the bowl is restored, the float closes the needle valve, figure 90.

Under actual operating conditions, the float allows the needle valve to remain open just far enough to meter the fuel flow and maintain a very precise fuel level. It is impossible to overemphasize the importance of setting the float carefully so that the correct fuel level will be maintained under all operating conditions.

INCORRECT FLOAT LEVEL CAUSES PROBLEMS. If the level of the fuel in the bowl is too low, the air flowing through the venturi will have to lift the gasoline farther. As a result, fuel flow will be reduced in proportion to air flow and the mixture will be too lean. This can cause sluggishness and similar performance problems.

If the float level is high, figure 91, too much fuel will be discharged into the air stream and the mixture will be too rich. This condition can contribute to poor fuel economy and may cause performance problems. It can also cause or contribute to "hot starting" problems.

348

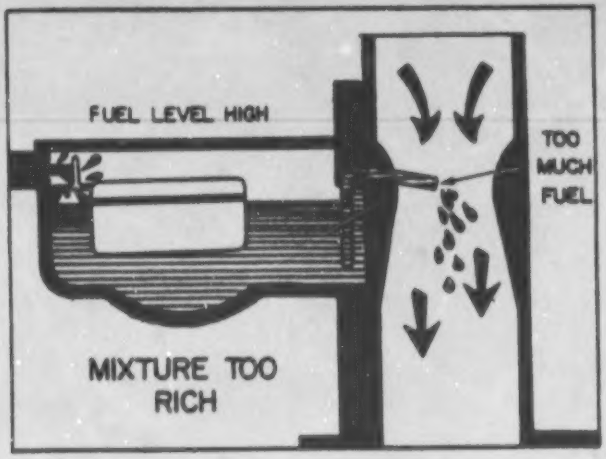


Figure 91. The Float Level Affects the Air-Fuel Ratio.

THE THROTTLE IS A FLOW VALVE. The throttle valve controls the amount of air-fuel mixture entering the intake manifold. It is simply an air-flow control valve. However, the design and exact location of this valve is very important. This will become evident when we discuss the relationship of the throttle valve to the idle and the transfer ports.

Feeding the Engine at Low Speed

Of course there is a lot more to a modern carburetor than a fuel bowl, float system, throttle valve, venturi and fuel discharge nozzle. So let's move on to the idle system and other systems required in a practical carburetor for a car or truck.

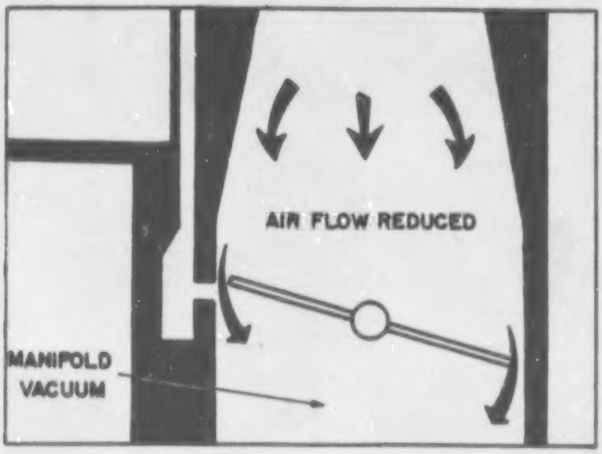


Figure 92. Reduced Pressure at the Idle Port.

WHEN THE THROTTLE VALVE IS CLOSED. At idle, air flow through the venturi is greatly reduced by the almost closed throttle valve, figure 92. The pressure drop in the venturi is very slight so no fuel is supplied by the main discharge nozzle. However, the space below the throttle valve is exposed to manifold vacuum. So, there is a low-pressure condition below the nearly closed throttle.

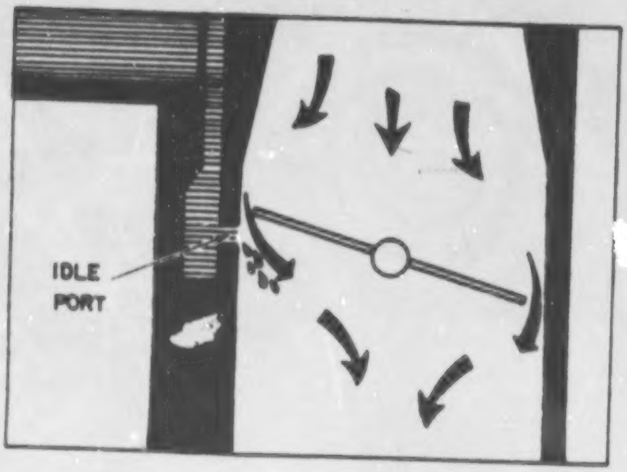


Figure 93. Fuel Flow at Closed Throttle.

The idle port is located just below the edge of the closed throttle valve. The small amount of fuel needed to keep the engine running at idle is discharged from the idle port and mixed with the air flowing past the nearly closed throttle valve, figure 93.

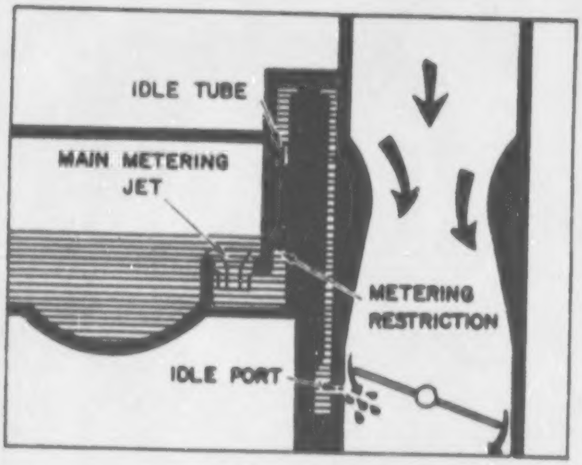


Figure 94. Fuel Flow is Limited by a Restriction.

FUEL FLOW AT IDLE IS METERED. The idle system is supplied by fuel flowing through the main metering jet. After leaving the jet, the fuel flows upward through the idle tube. Fuel flow is limited by the idle system metering restriction which is usually a calibrated opening at the lower end of the idle tube. Above the idle tube, the idle passage makes two quick right-angle turns and leads downward to the idle port, figure 94.

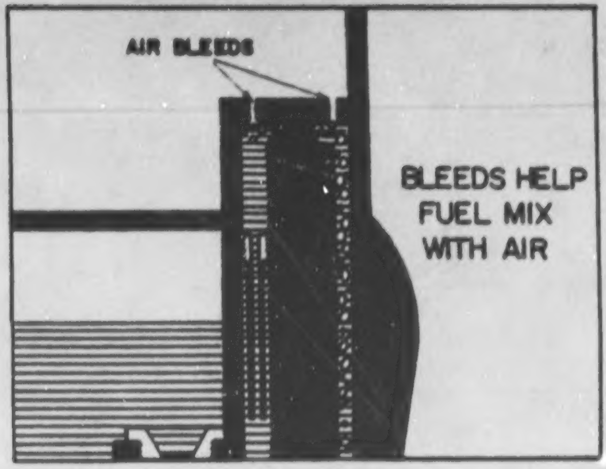


Figure 95. Air Bleeds Also Prevent Syphoning of Fuel.

THOSE ANTI-SYPHON AIR BLEEDS. Although the idle port is located below the level of the fuel in the fuel bowl, no syphoning action takes place. That's because one or more air bleeds at the upper end of the idle passage serve as vents so there can be no syphoning of fuel from the fuel bowl. Equally important, tiny air bubbles enter the fuel stream through the air bleeds. Aerating the fuel before it reaches the idle port helps the fuel mix more readily and uniformly with the air flowing through the carburetor, figure 95.

THE TRANSFER PORT ADDS AIR, TOO. At idle when the throttle valve is closed, additional air is bled into the idle system fuel stream through the transfer port. But we better explain why air bleeds in through the transfer port at closed throttle instead of fuel spilling out of it.

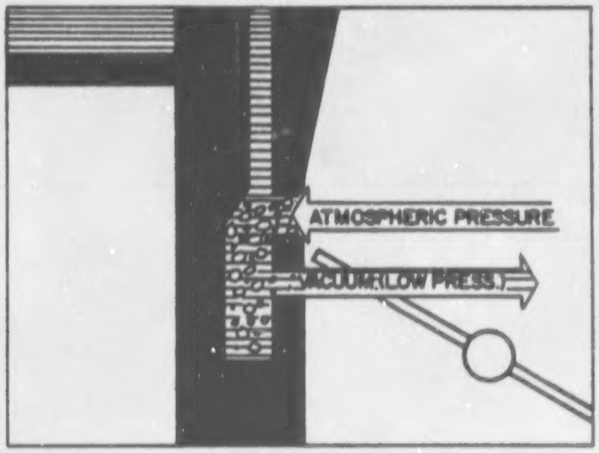


Figure 96. The Transfer Port Serves as an Air Bleed.

For all practical purposes, at closed throttle the pressure at the transfer port is at or near atmospheric pressure. However, below the throttle valve at the idle port there is manifold vacuum or low pressure. Because of this pressure difference, air flows in through the transfer port, mixes with the fuel and is discharged through the idle port, figure 96.

THE TRANSFER PORT ALSO SUPPLIES FUEL. When the throttle valve is opened slightly, the transfer port as well as the idle port is exposed to manifold vacuum. This causes fuel to flow from both the idle and the transfer port to supply the correct air-fuel ratio for low-speed, off-idle operation.

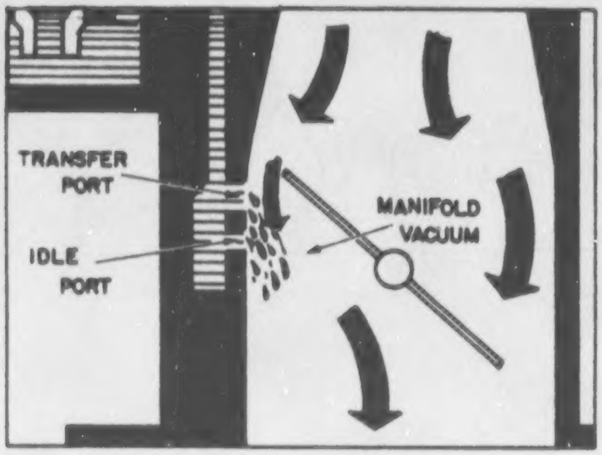


Figure 97. Transfer Port Exposed to Manifold Vacuum.

If it were not for the additional fuel supplied through the transfer port, the off-idle mixture would be much too lean and a low-speed flat spot would result. That's because opening the throttle slightly allows more air flow but there is no corresponding increase in the flow of fuel through the idle port because of the metering restriction at the lower end of the idle tube, figure 97.

IDLE MIXTURE ADJUSTMENT. So far we haven't considered the methods used to adjust the maximum amount of fuel flowing from the idle port. On the majority of carburetors, the mixture adjustment is accomplished by a fuel metering needle valve in the idle circuit near the idle discharge port, figure 98. Turning the screw clockwise reduces fuel flow to produce a leaner mixture and turning the screw counterclockwise allows more fuel to flow for a richer mixture. Two- and four-barrel carburetors have two complete idle systems and two idle mixture screws.

CARBURETORS WITH ADJUSTABLE AIR BLEED. Some carburetors, including some of our recent past model two-barrel and four-barrel carburetors, have one idle mixture adjusting screw for the two

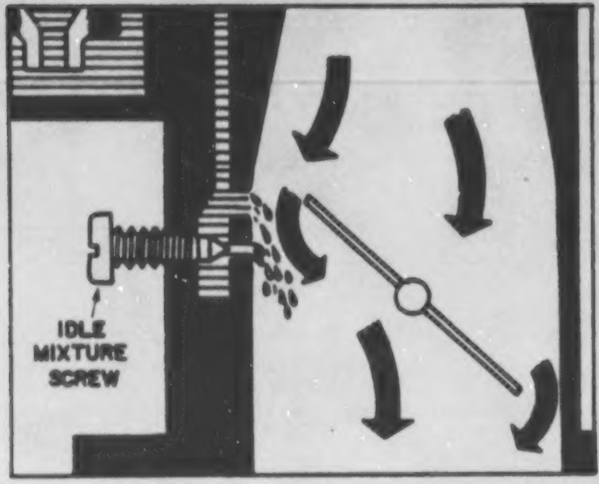


Figure 98. Idle Mixture Screw Controls Fuel Flow.

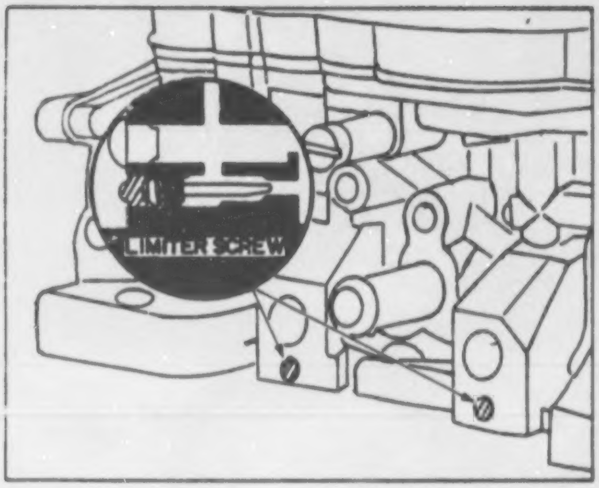


Figure 99. Idle Mixture Limiter Screws Are Sealed.

idle systems. Carburetors with this arrangement have idle mixture limiter screws which were adjusted, flow-tested and then sealed at the factory. This type screw limits the maximum amount of fuel that can be supplied at idle, figure 99.

To provide for idle mixture adjustment in service, carburetors with sealed idle mixture limiter screws have an adjustable air bleed, figure 100. Opening this screw lets more air bleed into the fuel in the idle passage to lean out the mixture and closing the idle adjusting cuts down on the air to make the mixture richer. On these carburetors, the idle mixture screw is an air bleed adjusting screw. Incidentally, this adjusting screw has a left-hand thread. As a result, it must be turned counterclockwise to increase the richness of the mixture and clockwise to make the mixture leaner.

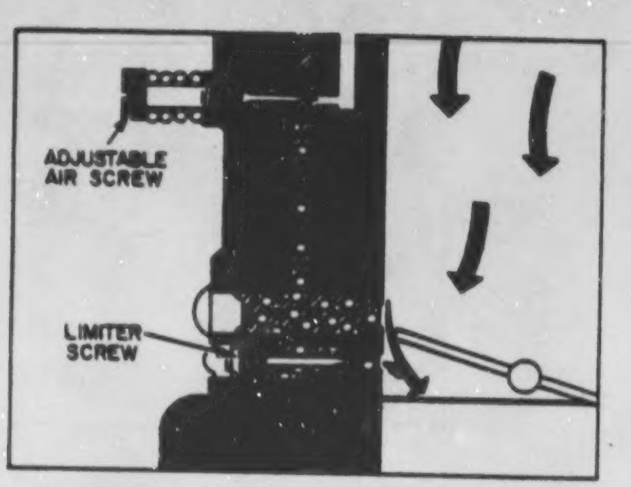

ADJUSTABLE AIR SCREW
LIMITER SCREW

Figure 100. The Idle Mixture Air Screw Has Left-Hand Thread.

In other words, the direction of rotation for richer or leaner mixtures is the same as it is for a conventional idle mixture screw.

THE HIGH-SPEED AND STEP-UP SYSTEMS

The idle and transfer ports supply the fuel needs for low-speed power operation. However, a high-speed system, and several auxiliary systems are needed to provide the richer mixtures required for sudden acceleration, maximum power and cold-engine starting.

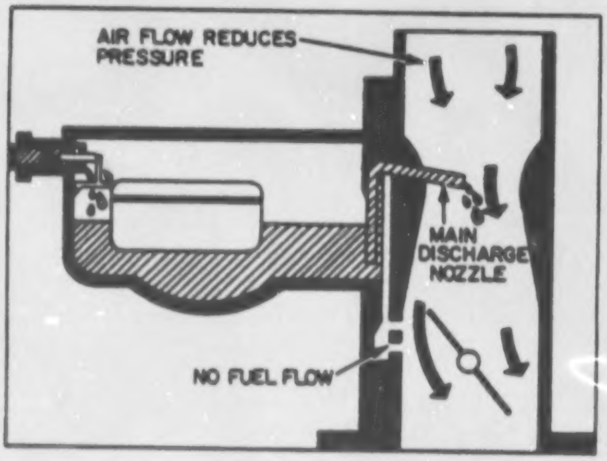

AIR FLOW REDUCES PRESSURE
MAIN DISCHARGE NOZZLE
NO FUEL FLOW

Figure 101. Fuel Flows from the Main Discharge Nozzle.

The High-Speed System

As the throttle is opened beyond the transfer port, air flow through the carburetor increases. The increased speed of the air flowing through the venturi reduces the pressure enough to cause fuel to flow from the main discharge nozzle, figure 101. At this point, the pressure at the end of the main nozzle is lower than the pressure at the transfer and idle ports. As a result, there is no further flow of fuel from these outlets. As a matter of fact, since the idle system is supplied from the main well, the high-speed system tends to draw the fuel out of the idle system passages.

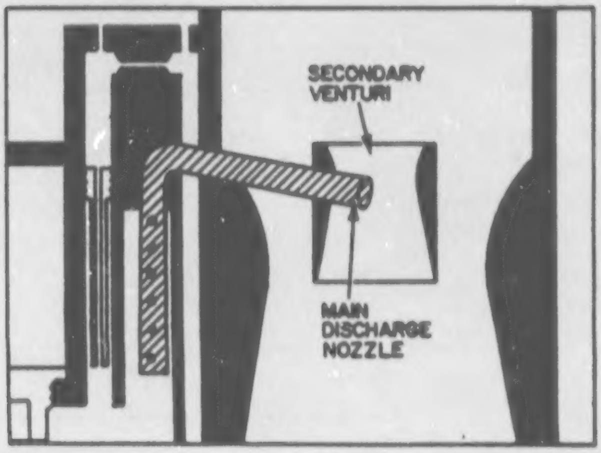


Figure 102. Carburetor with a Secondary Venturi.

DOUBLE AND TRIPLE VENTURIS. As you probably know, many carburetors carburetors have double and triple venturis. Where multiple venturis are used, the speed of the air flow increases as it passes through the successively smaller venturis. For example, if a double venturi is used, the main discharge nozzle extends into the smaller secondary venturi where the pressure drop is greatest, figure 102.

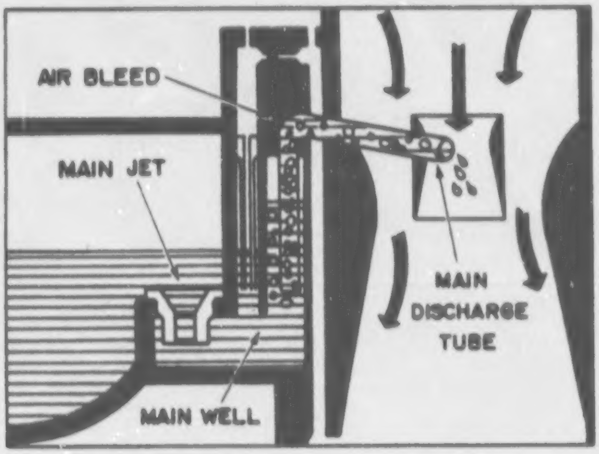


Figure 103. Air Bleeds Improve Atomization of Fuel.

THE MAIN JET METERS FUEL FLOW. The main jet, sometimes referred to as the high-speed jet, controls or meters fuel flowing from the float bowl and into the main well, figure 103. The lower end of the main discharge tube extends into the main well. The high-speed system picks up its fuel supply from the main well and discharges it into the stream of air flowing through the venturi.

The high-speed system also has one or more air bleeds. It is common practice to provide an air bleed at the upper end of the main well. Holes or perforations in the main discharge tube allow air to mix with the fuel flowing through the tube. Introducing air into the fuel stream helps break up the fuel and results in improved atomization---just as it does in the case of the idle system air bleeds.

BALANCED FUEL BOWL VENT. Up to now we have purposely avoided any discussion of the fuel bowl vent because we didn't want the vent details to complicate our illustrations of the basic fuel passages. The fuel bowl is externally vented only at idle, when the throttle is fully closed. The purpose of the external vent is to relieve any vapor pressure which might develop in the fuel bowl as a result of underhood engine heat. At all off-idle throttle positions, the fuel bowl is internally vented through the balance tube, figure 104.

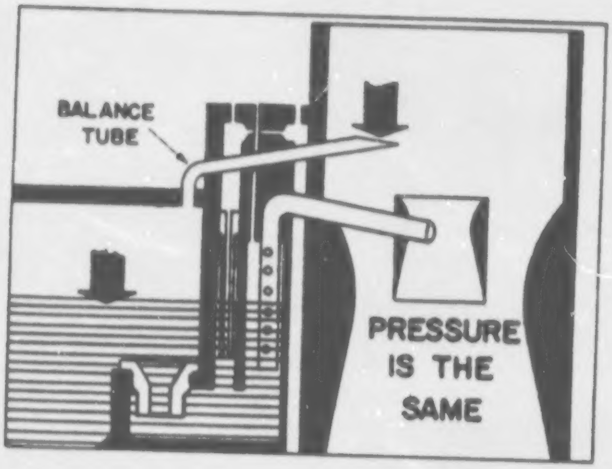


Figure 104. The Fuel Bowl Has an Internal Vent System.

The balance tube extends from the fuel bowl to the upper part of the carburetor air horn. As a result, the pressure is balanced which simply means that the pressure acting on the fuel in the bowl is the same as the pressure in the air horn. The balance tube automatically compensates for normal changes in restriction to air flow through the air cleaner. If the carburetor didn't have a balance tube, a dirty air cleaner would have "choke effect" on air flow causing the mixture to be excessively rich, figure 105.

358

DIRTY AIR CLEANER...
MIXTURE TOO RICH

Figure 105. The Balance Tube Eliminates Choke Effect.

The Step-Up and Power Systems

A simple high-speed system supplying a constant air-fuel ratio would be suitable for stationary engine application where speed and load are also constant. However, a fixed mixture ratio will not satisfy passenger car or truck requirements because both speed and load vary a great deal.

AIR-FUEL RATIO EXTREMES. To provide maximum power the high-speed system must feed the engine a mixture that is about 13 pounds of air to one pound of gasoline. For maximum part throttle economy and minimum exhaust emissions, the mixture ratio must be about 17 pounds of air to one pound of gasoline. Incidentally, air-fuel mixture ratios are normally expressed by weight...not by volume.

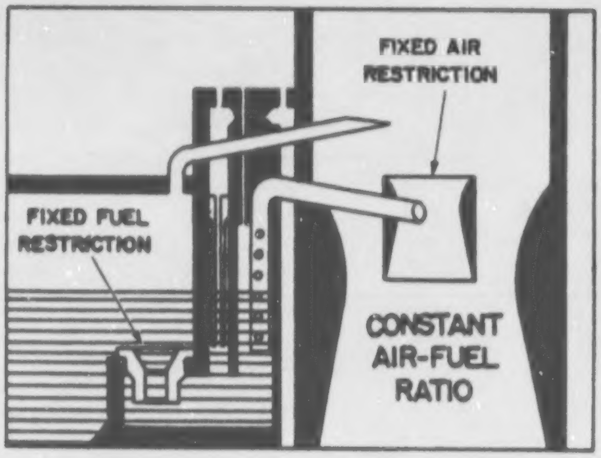

FIXED AIR RESTRICTION
FIXED FUEL RESTRICTION
CONSTANT AIR-FUEL RATIO

Figure 106. Simple High-Speed System.

THE JET AND VENTURI CONTROL THE RATIO. In the basic high-speed system we have been considering, the main jet represents a fixed fuel flow restriction and the venturi is a fixed air flow restriction, figure 106. This arrangement can only deliver a fixed or constant air-fuel ratio. To produce a variable air-fuel ratio some method of changing either the effective size of the venturi or the effective size of the main jet must be provided. In actual practice, one of several methods are used to vary the amount of fuel flow depending on engine operating conditions and requirements.

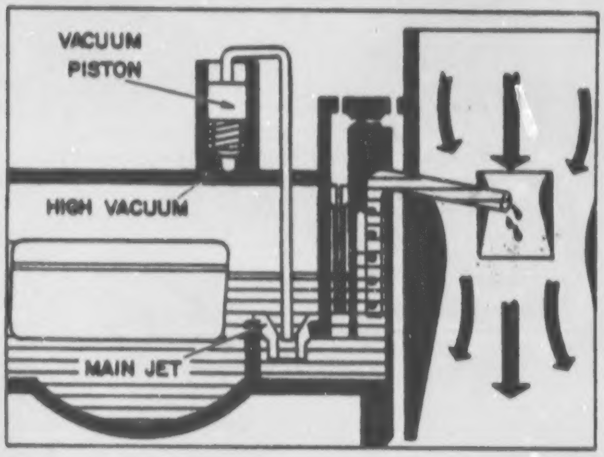


Figure 107. Metering Rod Provides Variable Mixture Ratio.

A METERING ROD PROVIDES A VARIABLE RATIO. One way to provide a variable air-fuel ratio is to use a metering rod. Where this method is used, the main jet is big enough to provide the richest mixture required for full engine power. Leaner mixtures are obtained by inserting a metering rod into the jet opening to restrict fuel flow, figure 107.

Since engine vacuum changes with air-fuel mixture requirements, a vacuum piston or a vacuum diaphragm can be used to control the metering rod. Under constant speed and load conditions manifold vacuum is high and a lean mixture is desirable for maximum economy and minimum exhaust emissions. In carburetors equipped with a spring-loaded piston and metering rod, high manifold vacuum pulls the piston downward so that the lower end of the rod extends into the jet. This reduces fuel flow through the jet to provide the required lean air-fuel ratio.

RICHER MIXTURE FOR FULL POWER. When the throttle is wide open, for maximum acceleration or for climbing a steep grade, manifold vacuum drops and the spring pushes the vacuum piston upward. This lifts the metering rod out of the jet to allow more fuel flow and provide the richer mixture needed for full engine power, figure 108.

355

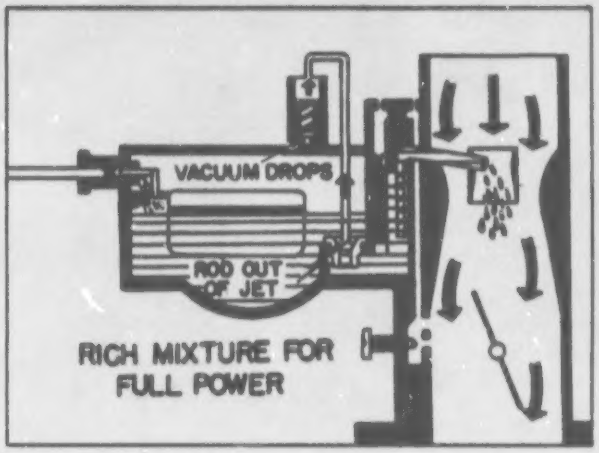


Figure 108. Vacuum Controls the Metering Rod.

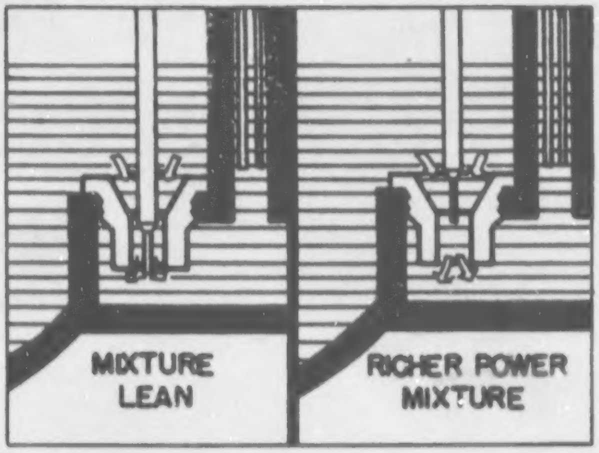


Figure 109. A Two-Step Metering Rod System.

TWO-STEP METERING RODS. Some carburetors have a two-step metering rod. When the large diameter extends into the jet, the high-speed circuit delivers a lean mixture. When engine vacuum drops, the piston lifts the rod so that the smaller diameter is in the jet. This provides a richer mixture for maximum power, figure 109.

AND THREE-STEP METERING RODS. Some carburetors have a three-step metering rod with a large upper diameter for lean economy mixture, a tapered center section provides a moderately lean transitional mixture ratio. A smaller diameter at the lower end provides the richer, maximum power, air-fuel ratio, figure 110.

SOME CARBURETORS HAVE A POWER JET. Another way to provide a variable air-fuel ratio is to use a power jet. This is in addition to the main jet. The opening and closing of the power jet can be

356

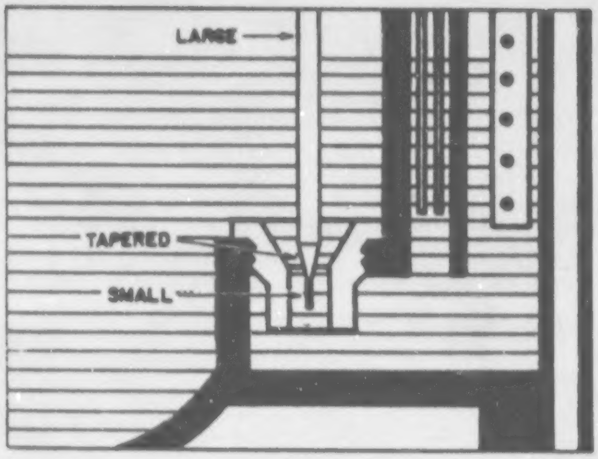


Figure 110. A Three-Step Metering Rod.

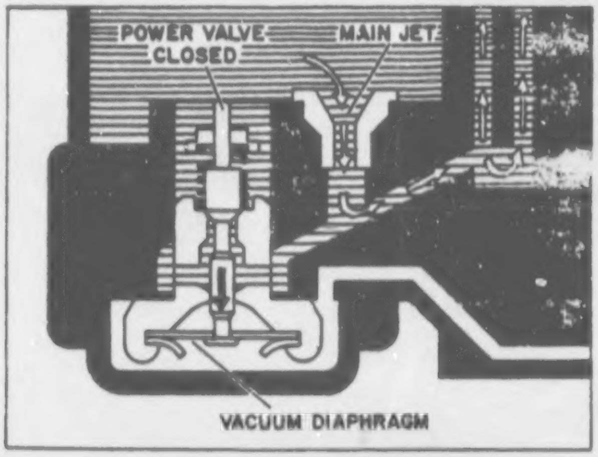


Figure 111. The Power Jet Is an Auxiliary Jet.

controlled by either a vacuum piston or by a vacuum diaphragm. If a vacuum piston is used, the setup is similar to that of a vacuum piston controlled metering rod. If a vacuum diaphragm is used, the basic arrangement is quite different so we will explain and illustrate the operation of a vacuum diaphragm controlled power jet.

VACUUM CLOSES THE POWER VALVE. The power valve is connected to a spring-loaded vacuum diaphragm. Under light-load operating conditions, high manifold vacuum moves the diaphragm against spring pressure to close the power valve, cutting off flow through the power jet, figure 111.

SPRING PRESSURE OPENS THE POWER VALVE. When the throttle is opened and manifold vacuum drops, the power valve is opened by the diaphragm spring. Fuel flows through both the power jet and the main jet to provide the richer mixture needed for full power, figure 112.

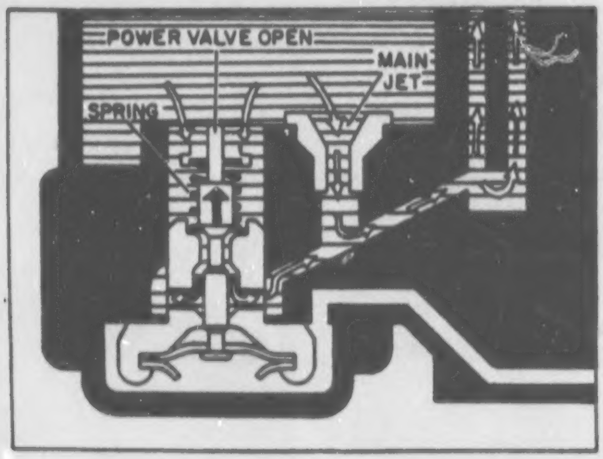


Figure 112. Fuel Flows Through Power and Main Jets.

Auxiliary Systems and Controls

In addition to the idle, high-speed, step-up and power systems, several auxiliary systems and controls are required in a practical modern carburetor for car or truck.

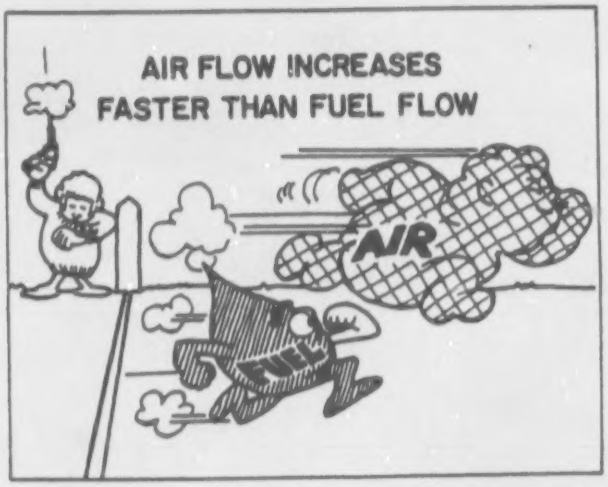

AIR FLOW INCREASES FASTER THAN FUEL FLOW
AIR
FUEL

Figure 113. The heavier Liquid Fuel Lags Behind.

WHEN THE ACCELERATOR IS FLOORBOARDED. When the throttle is opened suddenly for rapid acceleration, a rich mixture is called for. However, under this condition, air flow increases faster than fuel flow. Although the step-up metering system or power valve is open, the mixture tends to lean out. This would cause a momentary

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stumble. That's because the air is light and it speeds up easily while the heavier liquid fuel speeds up slowly and lags behind the rapidly increasing flow of air, figure 113.

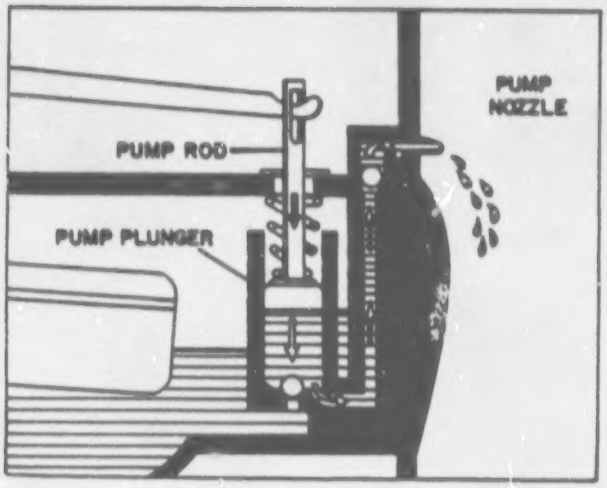
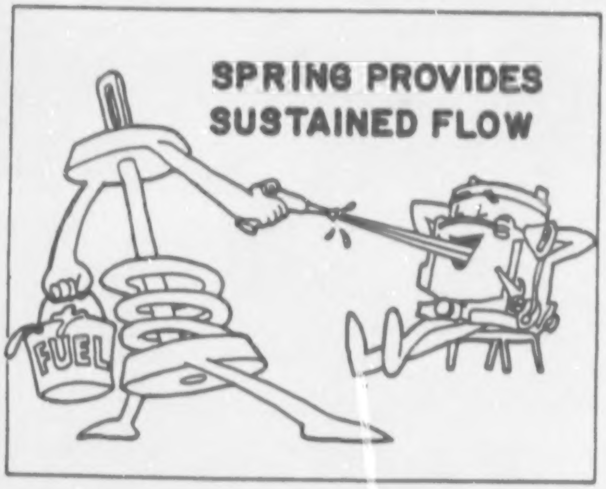


Figure 114. A Squirt of Fuel From the Accelerator Pump.

A SQUIRT OF FUEL DOES THE TRICK. When the throttle is suddenly opened, the accelerator pump delivers an extra squirt of fuel to enrich the air-fuel mixture and prevent the momentary stumble that might otherwise occur. Operation of the accelerator pump system is quite simple. When the throttle is opened, the throttle linkage releases the accelerator pump rod and the pump plunger is forced downward by the accelerator pump spring. The plunger pushed fuel out through the accelerator pump nozzle and into the stream of air flowing through the carburetor, figure 114.



373

Figure 115. The Pump Plunger Is Spring Actuated.

THE SPRING MAKES THE SQUIRT CONSISTENT. Spring actuation of the accelerator pump plunger insures an even, sustained flow of fuel, figure 115. If the plunger were operated directly by the throttle linkage, the rate and the duration of the fuel discharge would vary, depending on how fast the throttle was opened. The pump stroke and rate of discharge is designed to furnish just enough extra fuel to enrich the mixture until flow through the step-up system catches up with air flow.

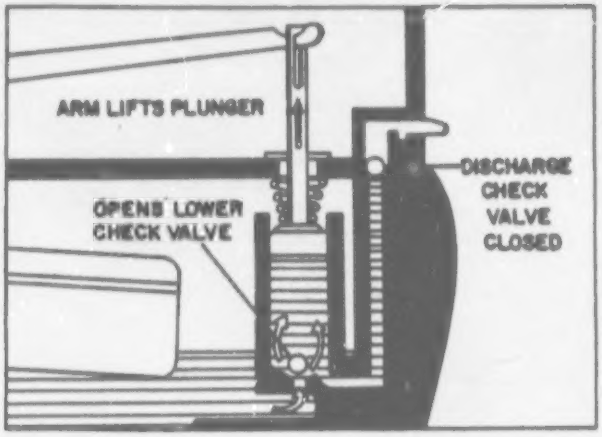

ARM LIFTS PLUNGER
OPENS LOWER CHECK VALVE
DISCHARGE CHECK VALVE CLOSED

Figure 116. Releasing the Accelerator Refills the Pump Well.

THE ACCELERATOR PUMP REFILL STROKE. When the throttle is released, the accelerator pump arm lifts the plunger upward compressing the pump spring. So, the plunger is again positioned for instant action. Upward movement of the plunger opens the lower check valve allowing fuel to flow into the pump well. At the same time, the upper or discharge check valves closes to prevent air from entering the well on the refill stroke, figure 116.

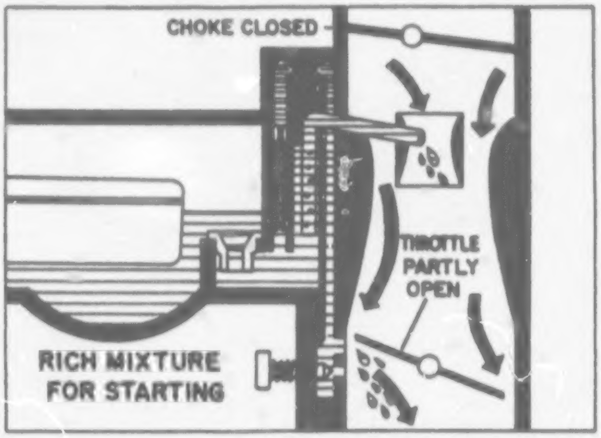

CHOKE CLOSED
THROTTLE PARTLY OPEN
RICH MIXTURE FOR STARTING

Figure 117. The Choke Valve Restricts Air Flow.

IT REALLY STARTS WITH THE CHOKE. When the choke valve is closed and the throttle valve is partly open, air flow is restricted but manifold pressure exists at the high-speed discharge nozzle, the transfer port and the idle port. As a result of this low pressure condition, fuel is discharged from all three of these outlets at cold engine cranking speeds. This provides the extremely rich mixture needed to start a cold engine, figure 117.

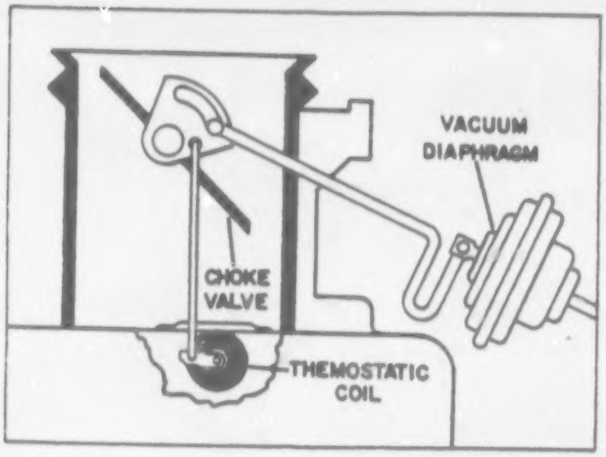


Figure 118. Well-Type Choke Valve Control.

THE WELL-TYPE AUTOMATIC CHOKE. The primary choke valve control is a thermostatic coil spring, usually located in a well in the intake manifold where it reacts to engine temperature. When the manifold and automatic choke are cold, the thermostatic spring coils up tighter. This moves a choke rod upward, pushing the choke valve into the closed position. As the manifold and the choke warm up, the thermostatic coil relaxes and this allows the choke valve to open, figure 118.

The vacuum kick diaphragm is an important secondary choke control. This device pulls the choke open a very precise amount as soon as the engine is started. Opening the choke slightly prevents an over-rich mixture which would cause the engine to load up and stall.

THE CHOKE UNCHOKES ITSELF. The design of the choke valve is in itself an important secondary choke control device. Since the choke shaft is off-center with respect to the choke valve, air entering the carburetor opens the choke valve when the engine starts and air flow through the air horn increases, figure 119.

THE CHOKE OPERATES THE FAST-IDLE CAM. The automatic choke linkage also rotates the fast-idle position. The fast-idle screw rests on the cam and holds the throttle open wider than the curb-idle position. This puts the throttle in the correct position to facilitate starting of a cold engine and helps keep the engine running smoothly while it is warming up, figure 120.

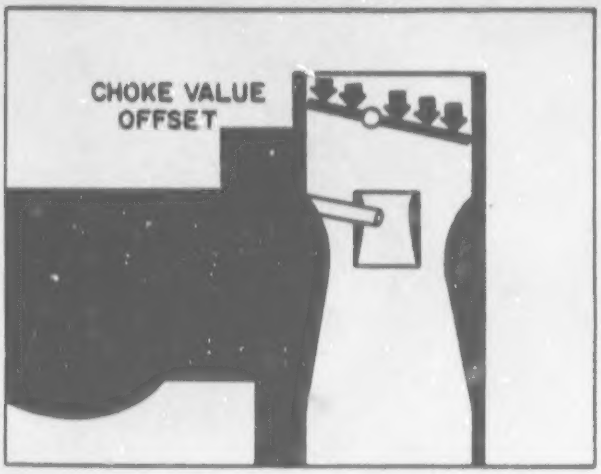


Figure 119. Air Flow Tends to Open the Choke Valve.

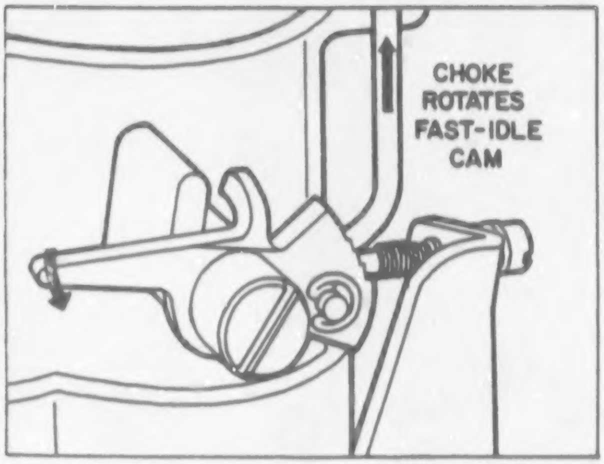


Figure 120. The Choke Positions the Fast-Idle Cam.

A WORD ABOUT EXTERNAL LINKAGES. It is most important to understand the design of the external linkages connected to the vacuum choke diaphragm, the fast-idle cam, bowl vent, accelerator pump, choke unloader and the well-type choke. These external links are purposely bent and shaped to produce precise movement of the levers and parts to which they are connected without interfering or touching other carburetor parts or links.

A certain amount of looseness is designed into each linkage. This working clearance, particularly at the connecting ends of each link, minimizes the possibility of sticking or jamming in operation. Clearance at the point of connection reduces binding or sticking caused by dirt or gum accumulation.

A FINAL WORD OF WARNING. External carburetor linkages are designed to operate dry and should not be lubricated. If oil is used, it will attract dirt, become gummy and interfere with correct linkage operation.

When setting up a carburetor, it is sometimes necessary to bend a link in order to obtain the correct choke opening, fast-idle cam position, choke vacuum-kick, etc. Each link has a curve, a bend or a loop that was specifically designed into the rod for the purpose of providing an adjusting or "bending point."

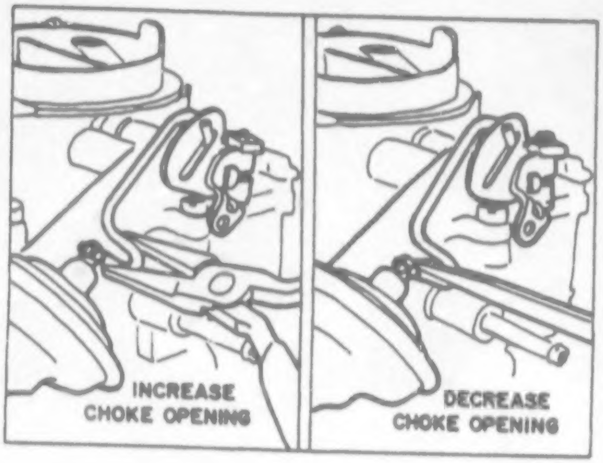


Figure 121. Increasing or Decreasing Vacuum Kick Opening.

When you adjust any carburetor linkage, bend the link only in the place specified in your Service Manuals. For example, when adjusting the vacuum kick, the only correct place to bend the link is at the U-shaped loop provided in the choke diaphragm link, figure 121.

HEAT CONTROLS

When an engine is first started, the cold metal of the intake manifold causes part of the air-fuel mixture to condense into a liquid on the way into the engine's combustion chambers. To prevent this, a heat control valve or heat riser is used. This valve is merely a butterfly valve placed in the exhaust manifold and controlled by a bi-metal spring. When the engine is cold the spring closes the butterfly valve and causes exhaust gasses to be circulated through a special passage in the intake manifold. Thus the intake manifold is heated and fuel vaporization is improved. As the engine warms up, the heat causes the bi-metal spring to relax and exhaust gasses are no longer circulated through the intake manifold, figures 122 and 123. This valve is mounted off center on its shaft so that even when in a closed position exhaust gasses can temporarily force it open if the engine speed is increased. Care must be taken when installing a new valve. If it is put

363

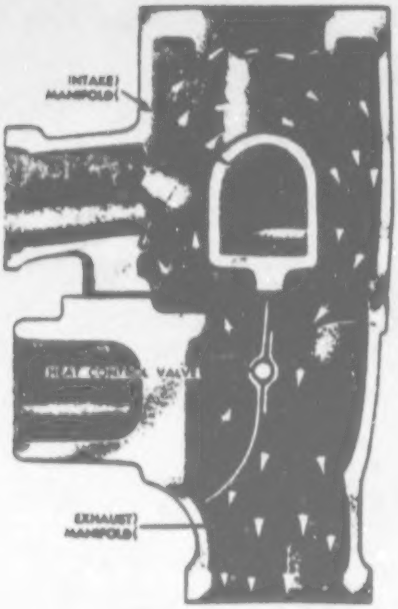


Figure 122. Intake Manifold and Heat Riser.

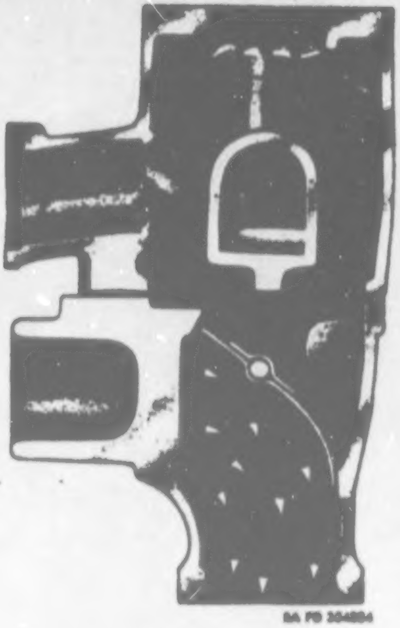


Figure 123. Intake Manifold and Heat Riser.

in the wrong way exhaust gasses will force it closed instead of opening it. If this valve gets stuck open, poor fuel vaporization will result. If it gets stuck closed, it will cause and excessive heat build up that can damage the engine.

AIR CLEANERS

An air cleaner filters the air entering the engine, acts as a flame arrester in case of engine backfire, and silences the noise of air entering the engine. Most vehicles today use an air cleaner with a disposable paper element. The element should be replaced at the manufacturer's specified interval or sooner if the vehicle is operated in a dusty area. Care should be taken when installing the air cleaner. Make sure the wing nut that holds it on the carburetor is not put on too tight, as this may cause the top of the carburetor to warp.

GOVERNORS

Governors are used on automotive engines to control maximum engine speed and prevent excessive wear. If engine speed is not controlled, it is possible for the speed of rotation to break the crankshaft and cause the engine to fly to pieces. There are four basic types of governors: (1) centrifugal, (2) vacuum velocity, (3) vacuum (also called centifugal vacuum), and (4) velocity.

Centrifugal Governors

The centrifugal governor consists of two weighted arms attached to a spindle. The spindle is connected by linkage to a throttle

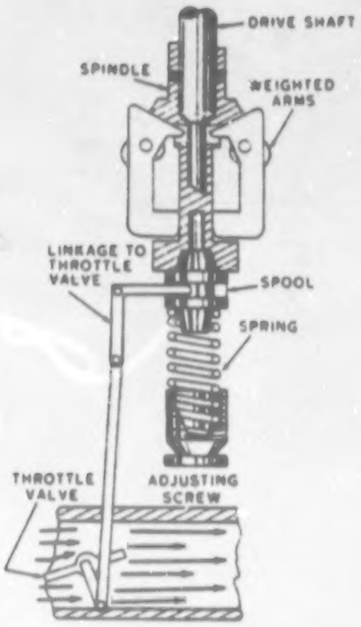


Figure 124. Throttle Valve Open.

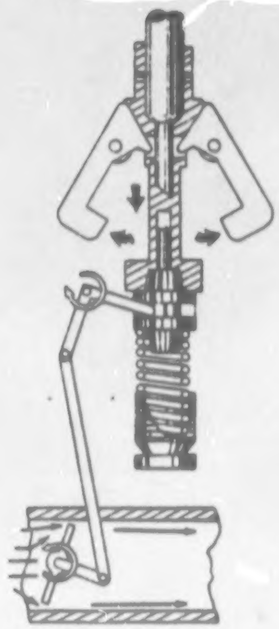


Figure 125. Throttle Valve Closed by Governor Action.

valve. The drive shaft, driven from the camshaft or accessory drive of the engine, drives the spindle, figures 124 and 125. Any action on the weighted arms will affect the passage of the air-fuel mixture from the carburetor to the engine cylinders. As the engine operates and the spindle rotates, the weights will tend to fly out, but they will be held in place by the spring and the throttle valve will remain open. As engine speed increases, the weights will overcome the spring and close the throttle valve, figure 125. A screw at the end of the spring serves as the adjusting screw.

Velocity Governors

Velocity governors are mounted between the carburetor and the intake manifold. They contain a butterfly valve mounted off center on a shaft. The shaft also has a spring connected that holds the butterfly valve open. As air rushes into the engine cylinders it tends to push the butterfly valve closed against spring tension. As engine speed increases and more air rushes past this butterfly valve the spring tension is overcome and the valve closes to restrict the volume of air-fuel mixture going to the engine, and reduces engine speed. An adjusting screw is provided to change spring tension for various governor settings, figure 126.

Vacuum Velocity

This type of governor mounts and operates in the same manner as the velocity governor except that it has a vacuum piston in addition to the butterfly valve and spring. The vacuum piston is subject to intake manifold vacuum and keeps the butterfly valve from fluttering, figure 127.

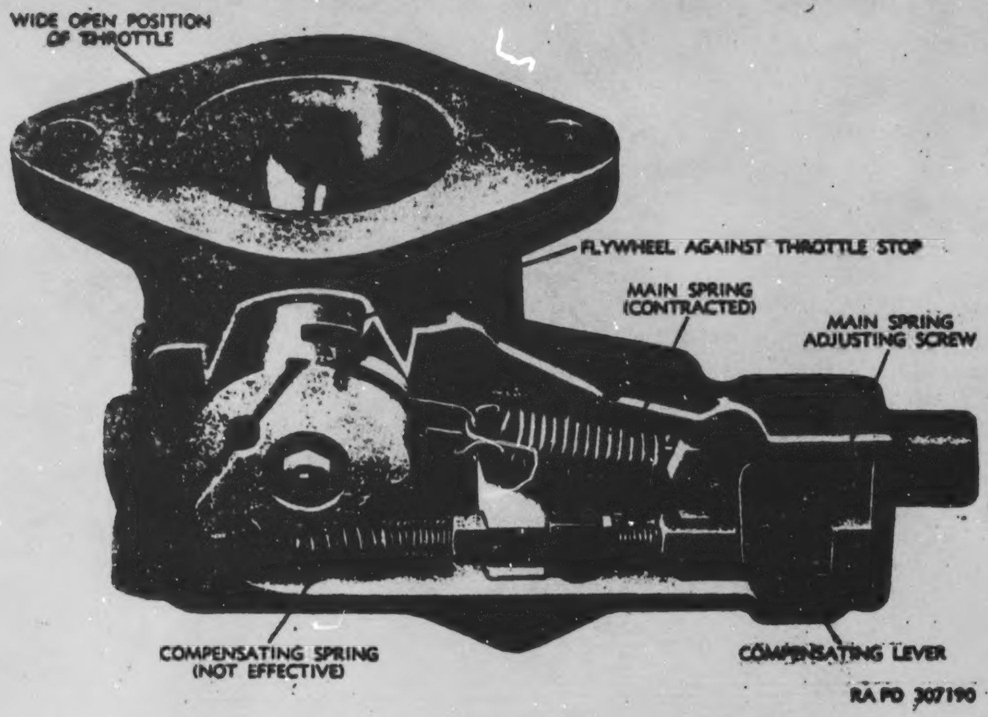

WIDE OPEN POSITION OF THROTTLE
FLYWHEEL AGAINST THROTTLE STOP
MAIN SPRING (CONTRACTED)
MAIN SPRING ADJUSTING SCREW
COMPENSATING SPRING (NOT EFFECTIVE)
COMPENSATING LEVER
RA PD 307190

Figure 126. Velocity Governor.

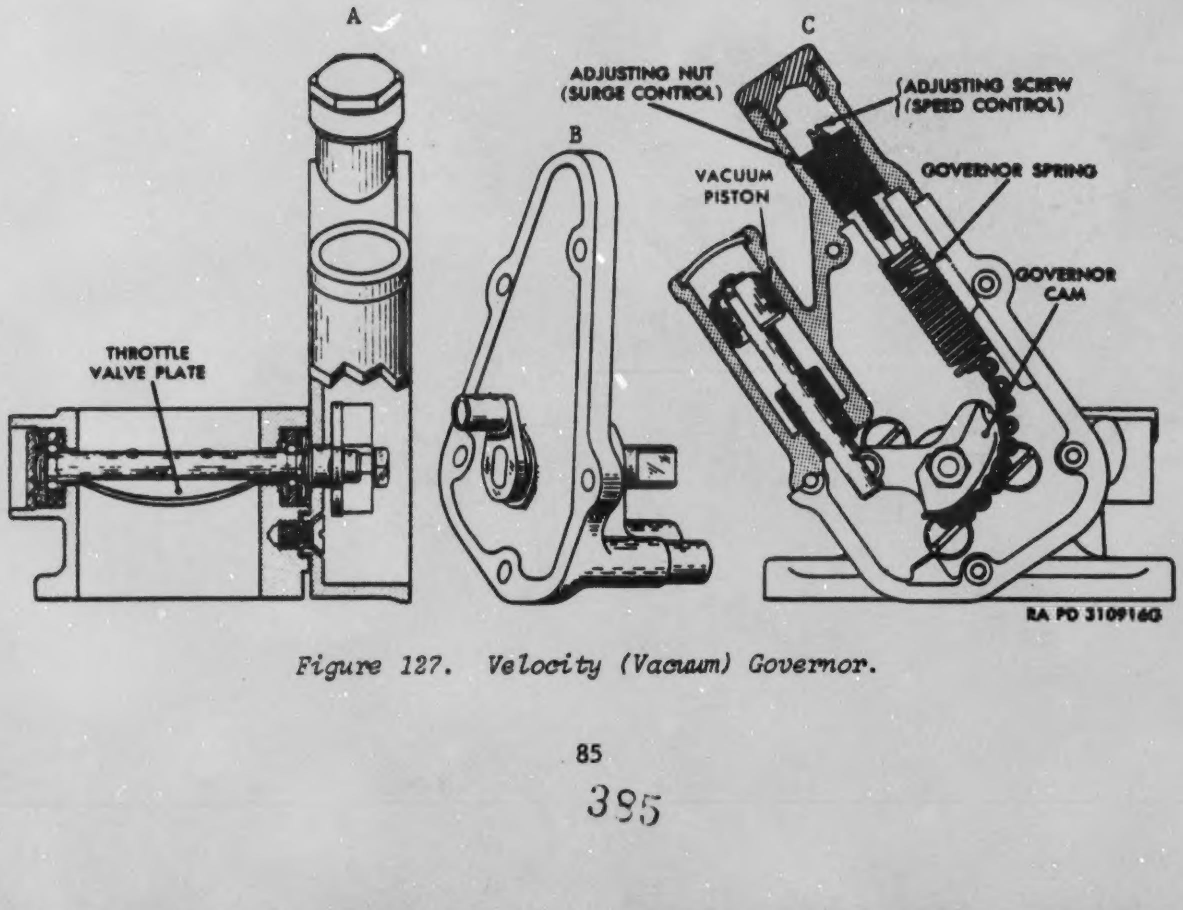

A
B
C
ADJUSTING NUT (SURGE CONTROL)
ADJUSTING SCREW (SPEED CONTROL)
VACUUM PISTON
GOVERNOR SPRING
GOVERNOR CAM
THROTTLE VALVE PLATE
RA PD 310916G

Figure 127. Velocity (Vacuum) Governor.

Vacuum or Centrifugal Vacuum

Both names apply to this type of governor. This governor uses a centrifugal setup to control the amount of vacuum metered, figure 127, to a vacuum diaphragm on the carburetor. This vacuum diaphram in turn limits the maximum throttle opening to control engine speed.

SUMMARY

This chapter has covered the basic construction and operating principles of carburetors and governors. One of the most important aspects of carburetion is the division of the carburetor into circuits or systems that are used to enable the engine to perform a specific operating function. When carburetor problems occur, this knowledge can then be used to determine what circuit or circuits are at fault and what extent of repair will be necessary.

QUESTIONS

1. How is a pressure differential used to move fluids?

2. Explain the principle of a venturi.

3. Explain what happens in a carburetor while it is changing from the low speed circuit to the high speed or main circuit.

4. What is the purpose of the carburetor balance tube?

5. What carburetor circuits operate when the accelerator pedal is suddenly depressed?

6. During what range of engine operation is the power valve open?

7. Why is an air bleed necessary in the idle circuit? In the main circuit?

8. What is the purpose of a governor?

9. What types of governors were discussed?

10. For each of the following ranges of engine operation, list the corresponding carburetor circuit or circuits that would be operating:

    a. Sitting at a stop light.
    b. Starting a cold engine.
    c. Going up a steep hill with a heavy load.
    d. Cruising on the highway at a steady 60 mph.
    e. Suddenly increasing the throttle opening.

SERVICE, REPAIR AND ADJUSTMENT OF CARBURETORS AND GOVERNORS

OBJECTIVES

At the conclusion of this lesson you will be able to repair, service, and adjust carburetors and governors to manufacturer's specifications.

INTRODUCTION

So far, the study of carburetion has been limited to a discussion of how carburetors operate. The next step is to explore the way they are repaired. Due to the many makes of carburetors and their similarities, a complete study of all of them would be extremely time consuming and of academic value only. Therefore, the following paragraphs will accomplish two things: (1) quickly review the areas that must be checked out before a carburetor is condemned, and (2) give a specific overhaul example on one type and make of carburetor.

INFORMATION

Before a carburetor is condemned and removed for overhaul, there are a number of things that should be tested since they affect the operation of the carburetor.

Think of an engine in terms of three operating areas: (1) compression (mechanical), (2) ignition (electrical), and (3) fuel system. The first action to take is a thorough test of the areas of compression and ignition. It is only after these areas have been pronounced satisfactory that the fuel system is dealt with.

If the fuel system is definitely at fault, then one more series of checks must be made before the carburetor can be condemned. Check and test as necessary the components of the fuel supply system. This would include such items as: (1) fuel tank and fuel level, (2) heat control valve, (3) throttle linkage, (4) fuel lines and filter (5) air cleaner and (6) intake manifold leaks. If no malfunctions are found in these areas, then move on to the carburetor. Remember to try and identify the carburetor malfunction in terms of the carburetor's circuits as they apply to various ranges of engine operation. By troubleshooting in this manner a complete carburetor overhaul may be avoided if the problem turns out to be an isolated defective part such as a bad accelerator pump.

CARBURETOR REPAIR

Disassembly

Since most carburetors disassemble in a similar manner, a specific disassembly procedure for any one type of carburetor is unnecessary

368

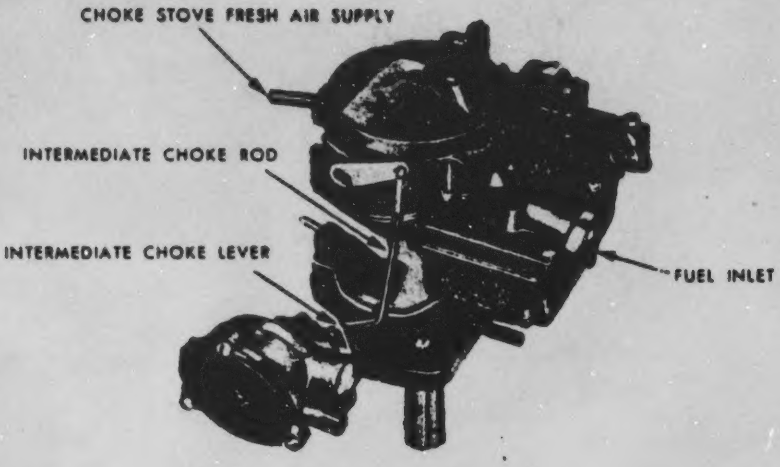

CHOKE STOVE FRESH AIR SUPPLY
INTERMEDIATE CHOKE ROD
INTERMEDIATE CHOKE LEVER
FUEL INLET

Figure 128.

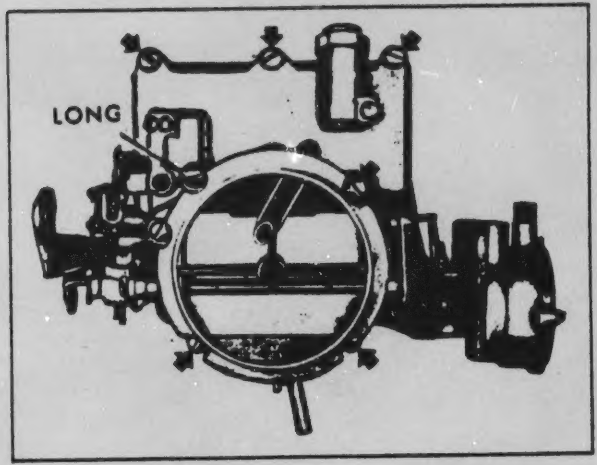
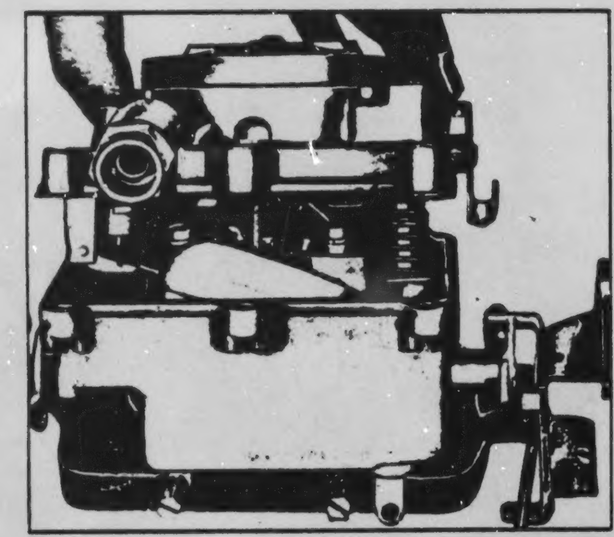


Figure 129.



388

Figure 130.

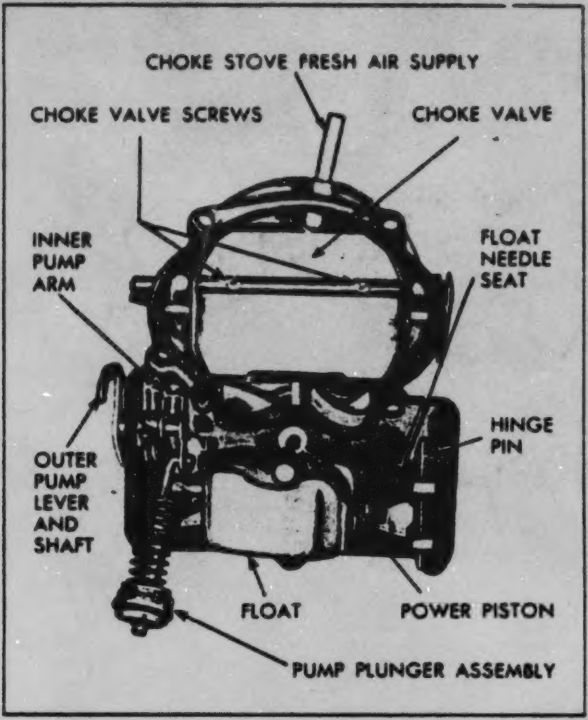

CHOKE STOVE FRESH AIR SUPPLY
CHOKE VALVE SCREWS
CHOKE VALVE
INNER PUMP ARM
FLOAT NEEDLE SEAT
HINGE PIN
OUTER PUMP LEVER AND SHAFT
FLOAT
POWER PISTON
PUMP PLUNGER ASSEMBLY

Figure 131.

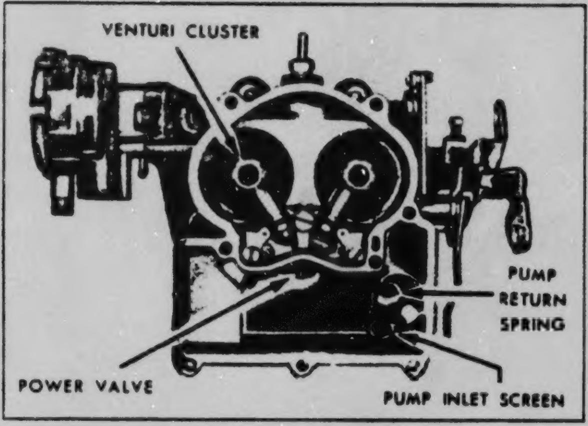

VENTURI CLUSTER
PUMP RETURN SPRING
POWER VALVE
PUMP INLET SCREEN

Figure 132.

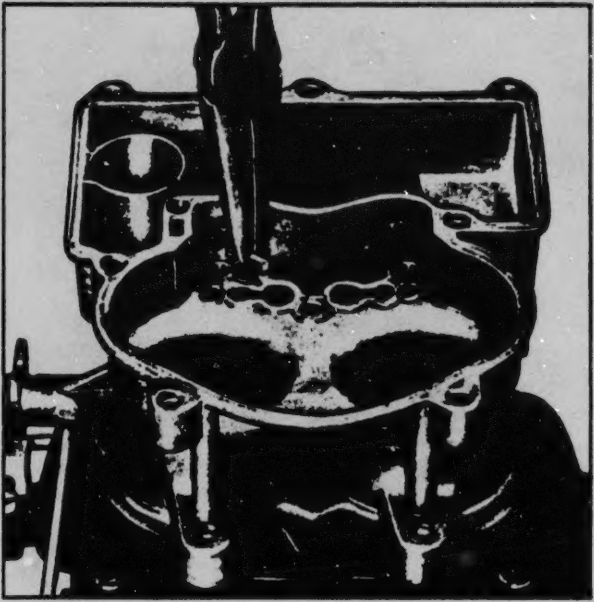


Figure 133.

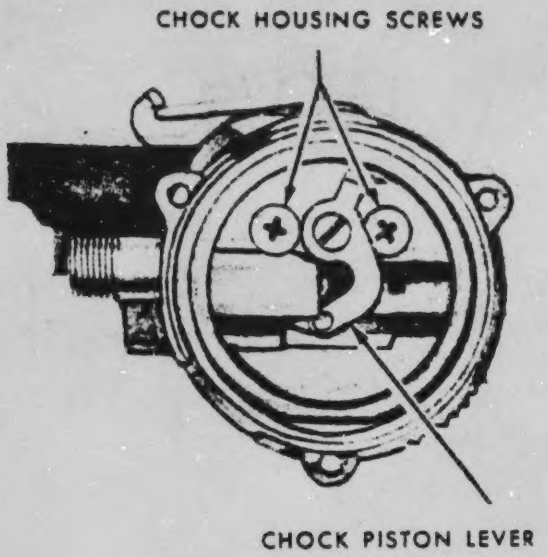

CHOCK HOUSING SCREWS
CHOCK PISTON LEVER

Figure 134.

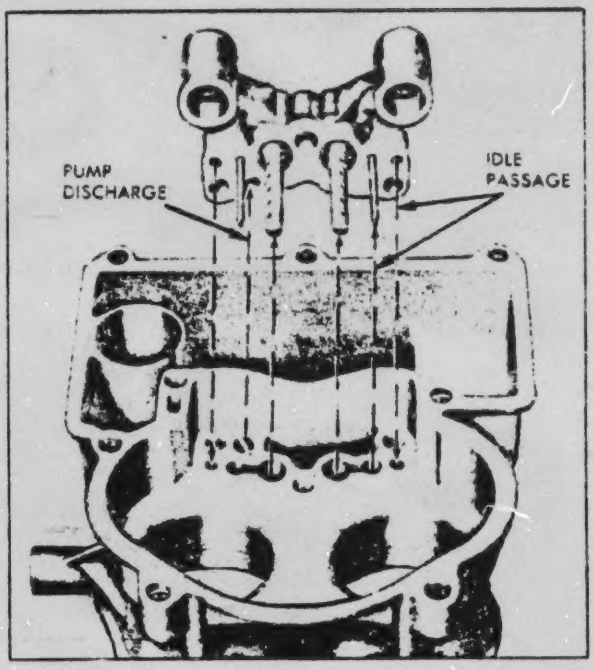

PUMP DISCHARGE
IDLE PASSAGE

Figure 135.

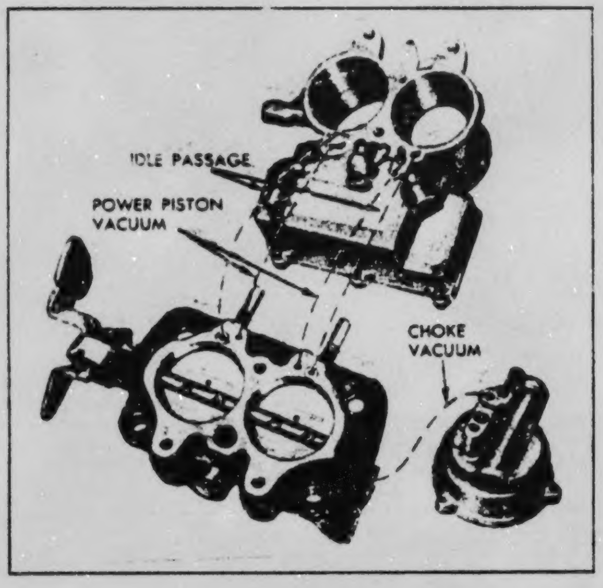

IDLE PASSAGE
POWER PISTON VACUUM
CHOKE VACUUM

Figure 136.

330

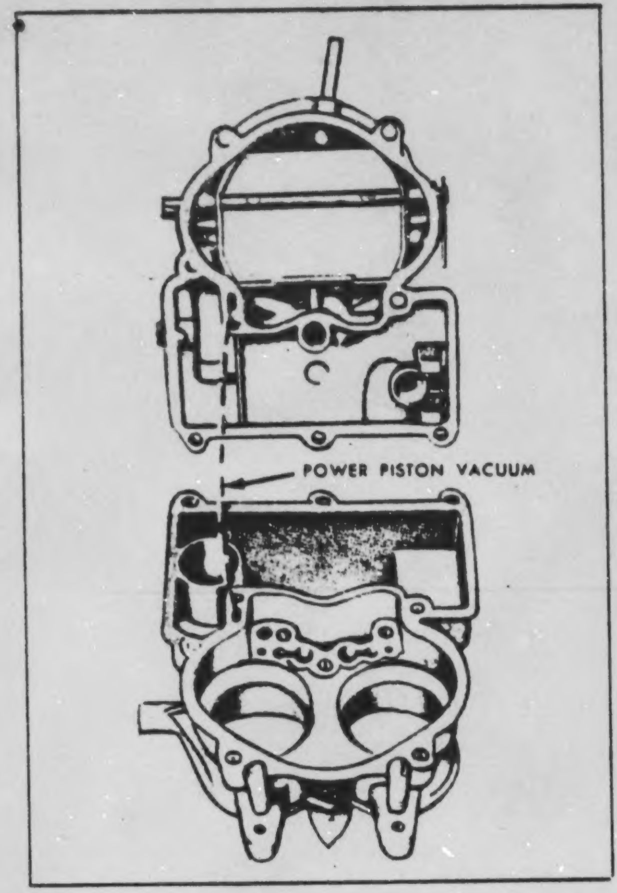

POWER PISTON VACUUM

Figure 137.

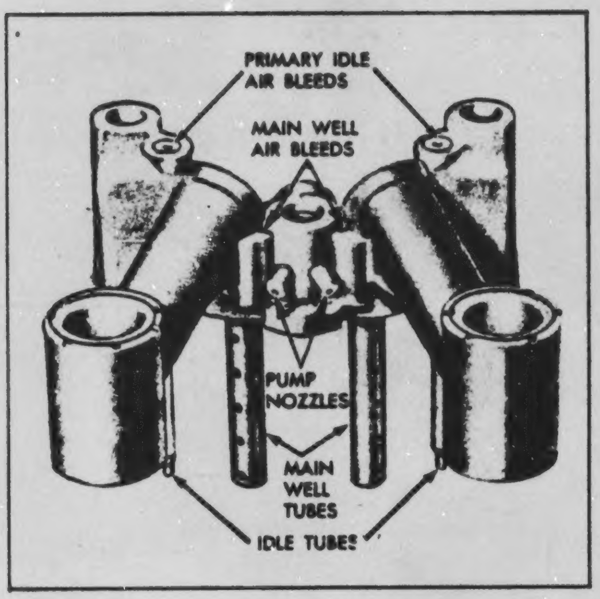

PRIMARY IDLE AIR BLEEDS
MAIN WELL AIR BLEEDS
PUMP NOZZLES
MAIN WELL TUBES
IDLE TUBES

Figure 138.

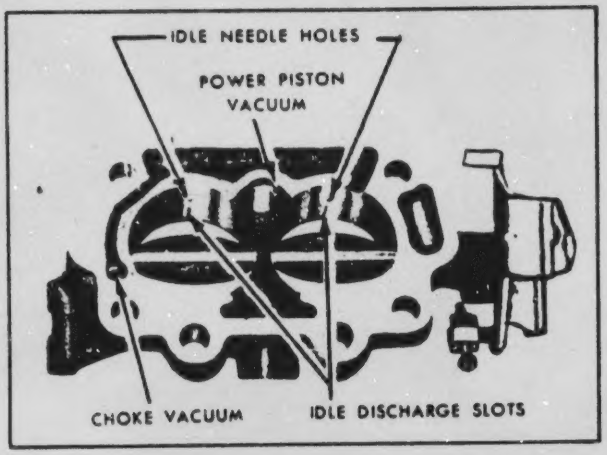

IDLE NEEDLE HOLES
POWER PISTON VACUUM
CHOKE VACUUM
IDLE DISCHARGE SLOTS

Figure 139.

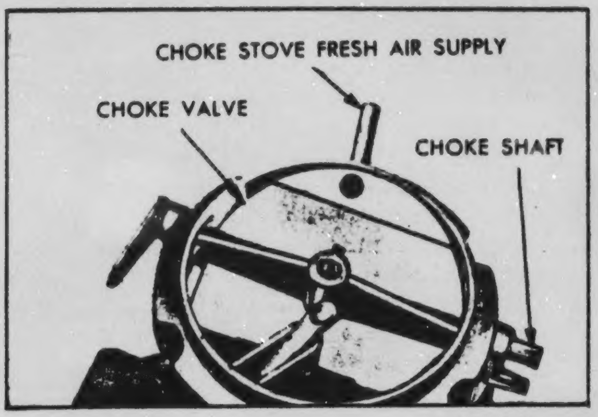

CHOKE STOVE FRESH AIR SUPPLY
CHOKE VALVE
CHOKE SHAFT

Figure 140.

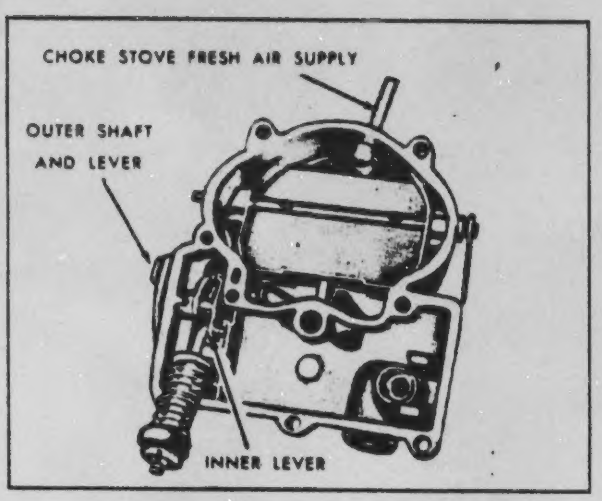


Figure 141.

at this time. A carburetor consists of three main assemblies: (1) the air horn (top of the carburetor, also called bowl cover), (2) the main body, and (3) the base or throttle flange. To disassemble a carburetor, disconnect any linkage between the three main assemblies, second remove the screws that hold the assemblies together, and third, after separating the three main sections, disassemble each one according to manufacturers procedures. Figures 128 thru 136 illustrate the disassembly of a Rochester 2GC (two barrel carburetor). Figures 128, 131, 132, 133 and 135 through 141 show the identification of the various operating parts and the fuel and vacuum passages.

Cleaning and Inspection

Thoroughly clean the metal castings of the carburetor in an approved solvent and then blow all passages in the castings with compressed air until they are dry. DO NOT put any plastic or rubber parts, or gaskets in the carburetor cleaner. DO NOT pass drills or wires through calibrated jets or passages as they may enlarge the orifices and seriously affect carburetor calibration.

Check all parts for wear. If wear is noted, defective parts must be replaced. Note especially the following nine items: (1) check float needle and seat for wear. If wear is noted, replace the assembly, (2) check float lip for wear and float for dents, check floats for gasoline leaks by shaking, (3) check throttle and choke shaft bores in throttle body and cover castings for wear or out of round, (4) inspect idle adjusting needle for burrs or ridges. Such a condition requires replacement, (5) inspect fast idle cam - if wear is noted on steps of the cam, it should be replaced as it may upset engine idle speed during the warm-up period, (6) inspect pump plunger leather. Replace plunger if cup is damaged, (7) inspect power piston and spring for burrs or distortion. Replace if necessary, (8) check all filter screens for dirt or lint. Clean and if they are distorted or plugged replace with new parts, and (9) inspect cluster casting. If any parts in castings are loose or damaged, cluter assembly must be replaced.

Reassembly

Always use new gaskets for reassembly. Reassemble each of the three main subassemblies according to the manufacturer's procedures and make the recommended adjustments, then put the subassemblies together and connect the external linkage. The carburetor is now ready to install on the engine before making the final adjustments. When repairing a carburetor, always remember to keep tools, working area, and parts, neat, orderly, and clean. This will make repair work easier, faster, and more accurate. Also when assembling a carburetor, be careful not to over tighten the screws that hold it together as this will cause various parts of the carburetor to warp.

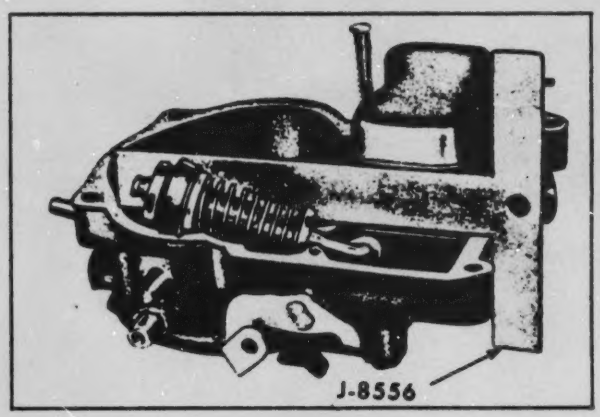


Figure 142.

CARBURETOR ADJUSTMENTS

Float Level Adjustment

With the air horn held upside down and the gasket in place and needle valve seated, there should be 5/8" ± 1/16" clearance between the lower edge of the float seam (sharp edge) at the toe end of the air horn gasket, figure 142. To adjust, bend float arm at the rear of the float.

Float Drop Adjustment

With the air horn right side up so that the float can hang free, the distance from the gasket surface to the lowest point of the float should be a maximum of 1 3/4" and can be measured using the float gauge, figure 143. To adjust, bend tang at rear of float towards the needle seat to decrease float drop and away from the needle seat to increase float drop.

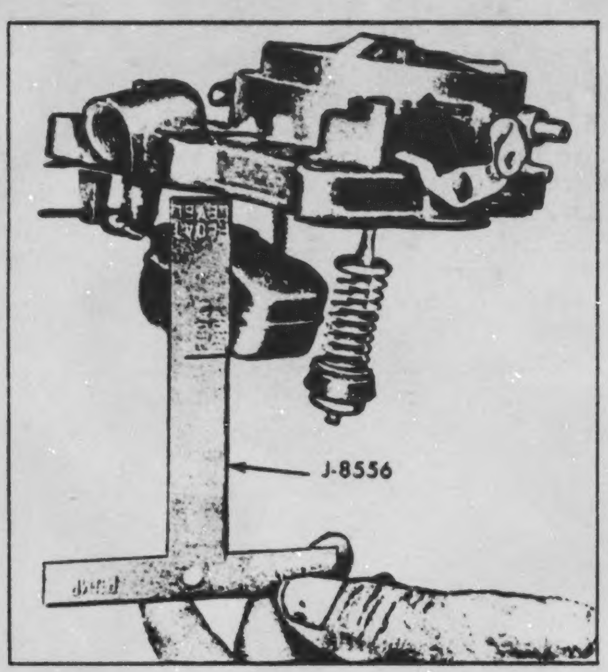


Figure 143. Float Gauge.

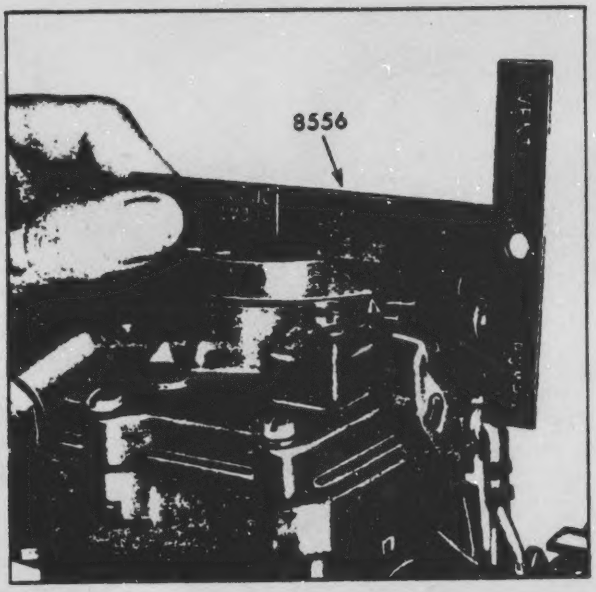


Figure 144. Air Cleaner Mounting Ring.

Accelerator Pump Adjustment

Place the special gauge on top of the air cleaner mounting ring as shown in figure 144. Then with throttle valves fully closed, the top surface of the pump rod should just touch the end of the gauge. Measurement should be 1 21/64" ± 1/32". Bend the pump rod to adjust.

.375

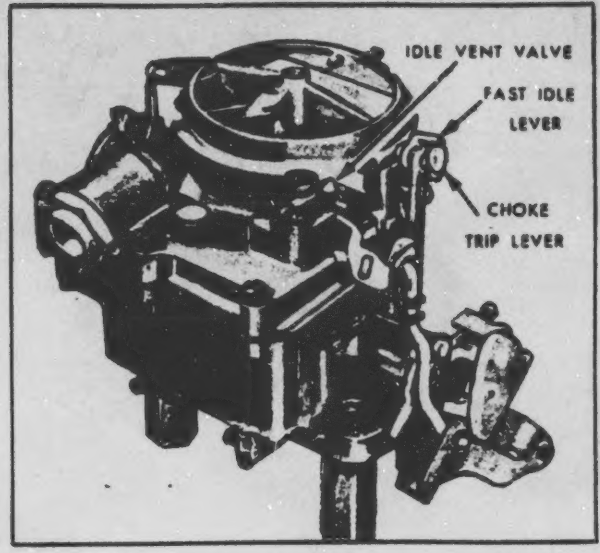

IDLE VENT VALVE
FAST IDLE LEVER
CHOKE TRIP LEVER

Figure 145. Fast Idle Lever.

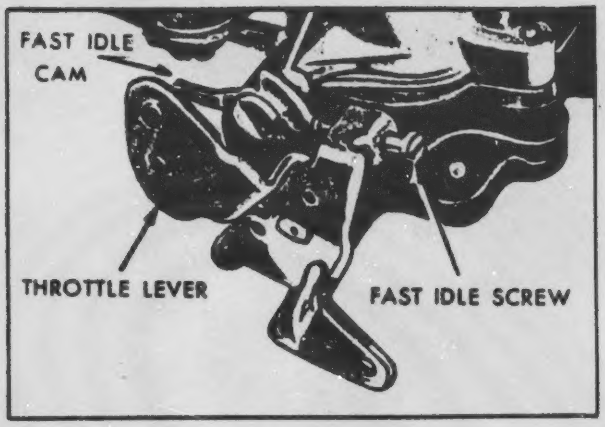

FAST IDLE CAM
THROTTLE LEVER
FAST IDLE SCREW

Figure 146. Fast Idle Cam.

Choke Rod Adjustment

With the thermostat cover set at index and the choke trip lever in contact with the fast idle lever, figure 145, locate the fast idle screw on the second step of the fast idle cam, next to the shoulder of the high step, figure 146. Finally, bend the tang on the fast idle lever so that the small end of a .080" wire gauge or drill, just fits between the inner side of the air horn and the upper edge of the choke valve, figure 147.

Idle Vent Adjustment

Note: Pump rod setting must always be made before making the idle vent adjustment.

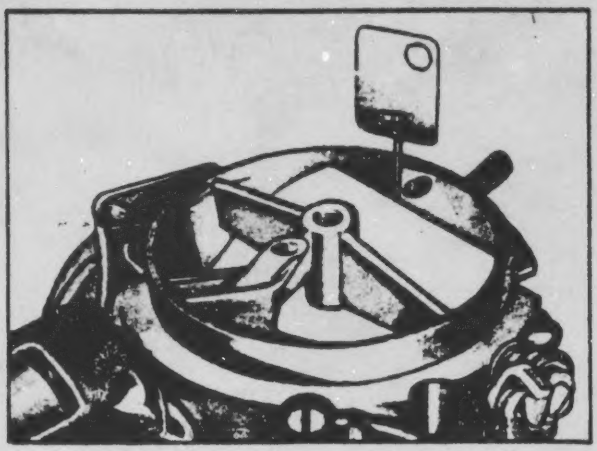


Figure 147. Choke Valve.

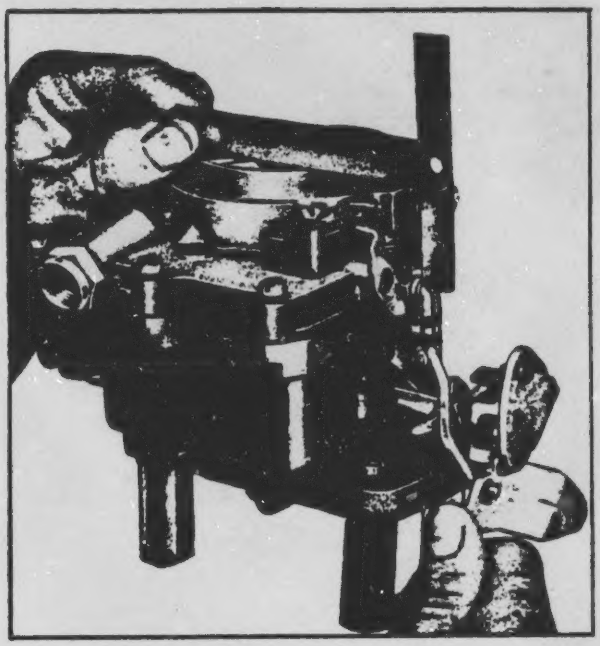


Figure 148. Air Cleaner Ring.

With the idle vent valve just closed, bend the tang, on the pump lever as necessary to obtain a dimension of 1 17/64" ± 1/64" between top of pump rod and top of the air cleaner ring, figure 148.

Different makes, models, or years of carburetors will have similar adjustments to be performed. They may not always be in exactly the same location as those discussed, or there maybe a few additional adjustments to be performed. In any case, always follow the manufacturer's procedures and diagrams as they are listed in the appropriate manual.

After the carburetor has been installed on the vehicle it's operation can be checked with an air-fuel ratio gauge, a chassis dynamometer, or the new exhaust emission control devices. These items will be covered in the performance part of this lesson.

GOVERNORS

Most types of governors are not repairable. When they become unservicable they are replaced with a new unit.

The few governors that are repairable vary so greatly in design characteristics that a detailed discussion of their repair would be impractical. Therefore a mechanic must refer to the applicable manufacturer's manuals for repair procedures. Governor adjustments must be handled in the same manner as their repair. It should be remembered that all governors are sealed to prevent tampering. Breaking of the seals must be done by authorized personnel only.

SUMMARY

This chapter has been concerned with the repair of carburetors and governors. The one most important thing to remember is not to assume the carburetor is the cause of an engine malfunction until the areas of compression, ignition, and all areas of the fuel supply system have been tested and found to be satisfactory. Remember; use the procedures and adjustments as listed in the appropriate manufacturer's manual.

QUESTIONS

1. How is a float tested for leaks?

2. What two adjustments are made on a float and why?

3. Explain the normal testing order used to locate an engine malfunction.

4. Why should the testing order referred to in question 3 be used?

5. Describe the cleaning procedures used in carburetro repairs.

6. Should carburetor passages be cleaned with a wire?

7. What carburetor parts must not be put in a carburetor cleaning solution?

WORKBOOK 3ABR47330-WB-202A

Technical Training

Automotive Repairman

ENGINES

7 May 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

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Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47330-WS-202A

380

ENGINE DISASSEMBLY AND REASSEMBLY

OBJECTIVES

Upon completion of this worksheet, you will be able to disassemble, perform parts inspection and servicing and reassemble engine using special tools and equipment.

EQUIPMENT

	Basis of Issue
Engine assembly	1/2 students
Mechanics toolkit	1/student
Measuring tools and devices	1/student
Spring testers	1/6 students

PROCEDURE

Using this worksheet for procedures and illustrations, and with guidance from your instructor, disassemble, inspect and service parts and components and reassemble an assigned engine.

SUPPLEMENT NO. 585

Remove and Replace pages 1, 2, 33 and 34 of this section in your CTS-2001 Manual.

ENGINE

SIX CYLINDER

MODELS BD-220, BD-240, BD-264 BG-220, BG-241, BG-265

(Engine Serial Number 605593 and Up)

INDEX

Subject — Page

CLEANING, INSPECTION, AND RECONDITIONING

- Camshaft and Bearings . . . 17
- Crankshaft and Bearings . . . 18
- Cylinder Block . . . 14
- Cylinder Head, Valves, and Related Parts . . . 25
- Flywheel and Ring Gear . . . 43
- Manifolds . . . 43
- Oil Filter . . . 41
- Oil Pan . . . 40
- Oil Pump . . . 38
- Pistons, Rings, Piston Pins and Connecting Rods . . . 21
- Rocker Arm Assembly, Push Rods, and Valve Lifters (Tappets) . . . 37
- Thermostat . . . 44
- Water Pump . . . 44

CRANKCASE VENTILATION SYSTEM . . . 62

ENGINE MOUNTINGS . . . 53

GENERAL DESCRIPTION . . . 8

REASSEMBLY AND INSTALLATION . . . 46

REMOVAL AND DISASSEMBLY . . . 9

SPECIFICATIONS . . . 3

TORQUE CHART . . . 7

TROUBLE SHOOTING . . . 55

INTERNATIONAL
HARVESTER

SPECIFICATIONS

ENGINE MODELS:	BD-220, BG-220	BD-240, BG-241	BD-264, BG-265
GENERAL DATA:			
Number of Cylinders	6	6	6
Bore (Inches)	3-9/16	3-9/16	3-11/16
Stroke (Inches)	3-11/16	4-1/64	4-1/8
Displacement (Cu. In.)	220.50	240.30	264.33
Compression Ratio	7.5	7.5	7.5
Brake Horsepower (Max.)	112.5 at 3800 RPM	140.8 at 3800 RPM	153.5 at 3800 RPM
Brake Horsepower (Net)	91.9 at 3400 RPM	115.1 at 3600 RPM	130.3 at 3600 RPM
Torque (Max.) (Ft. Lbs.)	194.4 at 2000 RPM	223.5 at 2000 RPM	248.0 at 2400 RPM
Torque (Net) (Ft. Lbs.)	178.0 at 1200 RPM	211.0 at 1400-1600 RPM	236.0 at 1200 RPM
Weight, bare (lbs.)	549	570	600
Weight, with standard accessories (lbs.)	635	656	687
Engine Serial Number Location	Stamped on block right side upper front corner.		
CAPACITIES:	Capacities vary between vehicle models. Refer to Operator's Manual.		
CYLINDER BLOCK:			
Cylinder Bore (Std.)	3.5593-3.5618	3.5593-3.5618	3.6875-3.6900
TUNE UP DATA:			
Firing Order	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Spark Plug Gap	.028-.033	.028-.033	.028-.033
Distributor Point Gap:			
New Points	.019	.019	.019
Reset	.016	.016	.016
Cam Angle (Degrees of Dwell)	28°-35°	28°-35°	28°-35°
Initial Timing Setting	4° B.T.D.C.	4° B.T.D.C.	2° B.T.D.C.
Idle Speed Range (RPM)	350-400	350-400	350-400
Maximum Recommended Speed (RPM)	3600	3400	3400
CRANKSHAFT:			
Number of Main Bearings	4	4	4
Main Journal Diameter	2.748-2.749	2.748-2.749	2.748-2.749
Main Bearing Clearance	.0014-.0040	.0014-.0040	.0014-.0040
End Play	.005-.010	.005-.010	.005-.010
Thrust taken by	3rd Main	3rd Main	3rd Main
Rod Journal (Crankpin) Diameter	2.373-2.374	2.373-2.374	2.373-2.374
Rod Bearing Clearance	.0011-.0032	.0011-.0032	.0009-.0032
Rod Side Clearance	.007-.013	.007-.013	.007-.013
CAMSHAFT:			
Bearing Journal Diameter:			
Front	2.109-2.110	2.109-2.110	2.109-2.110
Second	2.089-2.090	2.089-2.090	2.089-2.090
Third	2.069-2.070	2.069-2.070	2.069-2.070
Rear	1.4995-1.5005	1.4994-1.5005	1.4995-1.5005

SPECIFICATIONS (Continued)

ENGINE MODELS:	BD-220, BG-220	BD-240, BG-241	BD-264, BG-265
CAMSHAFT: (Continued)			
Bearing Clearance . . .	.001-.0035	.001-.0035	.001-.0035
End Play	.002-.010	.002-.010	.002-.010
Thrust taken by	Thrust flange	Thrust flange	Thrust flange
Timing Gear Backlash . .	.004-.007	.004-.007	.004-.007
CONNECTING RODS:			
Bearing Bore Diameter .	2.4995-2.5000	2.4995-2.5000	2.4995-2.5000
Piston Pin Bore Diameter	.8751-.8755	.8751-.8755	.8751-.8755
Bearing Clearance . . .	.0011-.0032	.0011-.0032	.0009-.0032
Side Clearance	.007-.013	.007-.013	.007-.013
PISTONS:			
Material	Aluminum alloy	Aluminum alloy	Aluminum alloy
Recommended Piston Clearance:			
Top of Skirt	.003	.003	.003
Bottom of Skirt	.002	.002	.002
Ring Groove Size:			
Top	.096-.097	.096-.097	.096-.097
Second	.1255-.1265	.1255-.1265	.1255-.1265
Third	.1885-.1895	.1885-.1895	.1885-.1895
Pin Bore Diameter . . .	.8751-.8752	.8751-.8752	.8751-.8752
PISTON FITTING: (Feeler Gauge Ribbon Checking)			
Width of Ribbon (Inch) . .	1/2	1/2	1/2
Thickness of Ribbon . .	.003	.003	.003
Tension on Scales (Lbs.) .	6-18	6-18	6-18
Desired Tension (Lbs.) .	12	12	12
PISTON PINS:			
Length (Inches)	2.945-2.956	2.945-2.956	2.945-2.956
Diameter	.8748-.8749	.8748-.8749	.8748-.8749
Pin Fit:			
In Rod	.0002-.0007	.0002-.0007	.0002-.0007
In Piston	.0002L-.0004L	.0002L-.0004L	.0002L-.0004L
PISTON RINGS:			
Compression Rings:			
Number used per Piston	2	2	2
Size (Thickness):			
Top	.0930-.0935	.0930-.0935	.0930-.0935
Second	.1235-.1240	.1235-.1240	.1235-.1240
Gap:			
Top.	.020-.030	.020-.030	.020-.030
Second	.020-.030	.020-.030	.020-.030
Side Clearance (Fit in Groove):			
Top	.0025-.0040	.0025-.0040	.0025-.0040
Second	.0015-.0030	.0015-.0030	.0015-.0030
Oil Control Rings:			
Number used per Piston	1	1	1
Size (Thickness): (Total 2 Rails, 1 Spacer) . .	.1795-.1875	.1795-.1875	.1795-.1875

SPECIFICATIONS (Continued)

ENGINE MODELS:	BD-220, BG-220	BD-240, BG-241	BD-264, BG-265
PISTON RINGS: (Continued)			
Gap:			
Spring Spacer	No gap at joint	No gap at joint	No gap at joint
Steel Rails	.015-.055	.015-.055	.015-.055
Side Clearance:			
(Fit in Groove).	.0025-.0040	.0025-.0040	.0025-.0040
VALVES:			
Intake Valves:			
Face Angle	30°	30°	30°
Seat Width (Inch) . . .	3/64-5/64	3/64-5/64	3/64-5/64
Seat Run-out (T.I.R.) (Max.)	.003	.003	.003
Valve to Rocker Arm Clearance (Hot) . . .	.024-.026	.024-.026	.024-.026
Stem Diameter	.3715-.3725	.3715-.3725	.3715-.3725
Stem Clearance in Guide	.0015-.0040	.0015-.0040	.0015-.0040
Exhaust Valves:			
Face Angle	30°	30°	30°
Seat Width (Inch)	5/64-7/64	5/64-7/64	5/64-7/64
Seat Run-out (T.I.R.) (Max.)	.003	.003	.003
Valve to Rocker Arm Clearance (Hot). . . .	.024-.026	.024-.026	.024-.026
Stem Diameter	.371-.372	.371-.372	.371-.372
Stem Clearance in Guide	.002-.0045	.002-.0045	.002-.0045
Slo-Roto Valve Cap-to-Valve Stem Clearance .	.001-.005	.001-.005	.001-.005
Valve Guides:			
Length (Inches)	2.41	2.41	2.41
Bore Diameter	.3740-.3755	.3740-.3755	.3740-.3755
Distance above Head (Inch)			
Intake	1-1/8±1/32	1-1/8±1/32	1-1/8±1/32
Exhaust	3/4±1/32	3/4±1/32	3/4±1/32
Press Fit in Head . . .	.0012-.003	.0012-.003	.0012-.003
Valve Springs:			
Free Length (Inches) . .	2.69	2.69	2.69
Pressure: (Lbs.)			
At 2.081 Inches (Valve Closed)	90-98	90-98	90-98
At 1.683 Inches (Valve Open)	151-160	151-160	151-160
Valve Lifters (Tappets):			
Diameter	.9965-.9970	.9965-.9970	.9965-.9970
Bore Diameter in Block.	.9990-1.0005	.9990-1.0005	.9990-1.0005
Clearance in Bore . . .	.002 -.004	.002-.004	.002-.004
Rocker Arms:			
Diameter of Shaft . . .	.748-.749	.748-.749	.748-.749
Bushing Bore Diameter .	.7505-.7520	.7505-.7520	.7505-.7520
Clearance on Shaft . . .	.0015-.004	.0015-.004	.0015-.004
Push Rods:			
Length: (Inches)	12-17/32	12-17/32	12-17/32
Outside Diameter (Inches)	3/8	3/8	3/8

SPECIFICATIONS (Continued)

ENGINE MODELS:	BD-220, BG-220	BD-240, BG-241	BD-264, BG-265
VALVES: (Continued)			
Valve Timing:			
Intake Opens (Before T. D. C.)	12°	12°	12°
Intake Closes (After B. D. C.)	38°	38°	38°
Exhaust Opens (Before B. D. C.)	55°	55°	55°
Exhaust Closes (After T. D. C.)	15°	15°	15°
Rocker Arm Clearance For Checking Valve Timing .	.033	.033	.033
OIL PUMP:			
Body Gear End Clearance	.0025-.0055	.0025-.0055	.0025-.0055
Pump Body to Gear Clearance	.0034-.0054	.0034-.0054	.0034-.0054
Pump Shaft Diameter . .	.4885-.4890	.4885-.4890	.4885-.4890
Pump Shaft Clearance in Bore	.0015-.0030	.0015-.0030	.0015-.0030
Body Gear Backlash . . .	.003-.006	.003-.006	.003-.006
Idler Shaft Diameter . .	.4845-.4855	.4845-.4855	.4845-.4855
Idler Gear Clearance on Shaft	.0015-.0045	.0015-.0045	.0015-.0045
OIL PRESSURES (HOT)*:			
Minimum (At Idle Speed) (Lbs.)	8-15	8-15	8-15
Maximum (At 1500 RPM) (Lbs.)	50-55	50-55	50-55
* (With SAE-30 oil at 200°F)			
OIL FILTER BASE:			
Pressure Regulator (High Pressure)			
Valve Spring:			
Free Length (Inches) . .	1.76	1.76	1.76
Test Length (Inches) . .	1.16	1.16	1.16
Test Load (Lbs.) . . .	28.8	28.8	28.8
Filter By-Pass (Low Pressure)			
Valve Spring:			
Free Length (Inches) . .	1.80	1.80	1.80
Test Length (Inches) . .	1.02	1.02	1.02
Test Load (Lbs.) . . .	9.7	9.7	9.7
FLYWHEEL HOUSING:			
Permissible Run-out . .	.000-.010	.000-.010	.000-.010
THERMOSTAT (STD.)			
Starts to Open at	158°-163°	158°-163°	158°-163°
Fully Open at	183°	183°	183°

TORQUE CHART

Location	Thread Size	Recommended Torque (Ft. Lbs.)*
Crankshaft Main Bearing Cap Bolts	1/2 - 13	75 - 85
Cylinder Head Bolts	1/2 - 13	85 - 95
Engine Front Support Bracket-To-Crankcase	1/2 - 13	35 - 45
Oil Filter Shell-To-Base Bolt	1/2 - 13	40 - 50
Starting Motor Mounting Bolts	1/2 - 13	75 - 85
Camshaft Gear Nut	1 - 20	110 - 120
Crankshaft Pulley Nut	1 - 14	90 - 100
Flywheel Housing Or Adapter Housing Bolts	7/16 - 14	45 - 50
Flywheel-To-Crankshaft Bolts	7/16 - 20	70 - 80
Generator Bracket-To-Crankcase Bolts	7/16 - 14	30 - 40
Oil Filter-To-Crankcase Bolts	7/16 - 14	40 - 50
Carburetor-To-Manifold (220, 240, 241)	3/8 - 24	23 - 28
Camshaft Thrust Flange Bolts	3/8 - 16	25 - 30
Connecting Rod Bolts	3/8 - 24	45 - 55
Engine Front Support Brackets-To-Crankcase Bolts	3/8 - 16	25 - 30
Front Plate-To-Crankcase	3/8 - 16	25 - 30
Gearcase Cover-To-Crankcase	3/8 - 16	25 - 30
Intake Manifold-To-Exhaust Manifold	3/8 - 16	25 - 30
Intake Manifold-To-Exhaust Manifold	3/8 - 24	23 - 28
Manifold-To-Cylinder Head Bolts	3/8 - 16	25 - 30
Water Pump-To-Crankcase Bolts	3/8 - 16	25 - 30
Carburetor-To-Manifold (264, 265)	5/16 - 24	9 - 11
Coil Mounting Bolts	5/16 - 18	14 - 16
Cylinder Head Cover Bolts	5/16 - 18	14 - 16
Fuel Pump Mounting Bolts	5/16 - 18	8 - 10
Gear Case Cover-To-Plate	5/16 - 24	9 - 11
Generator-To-Mounting Bracket	5/16 - 24	8 - 10
Generator Strap-To-Generator	5/16 - 18	14 - 16
Oil Filter-To-Crankcase	5/16 - 18	14 - 16
Oil Pan-To-Crankcase	5/16 - 18	14 - 16
Oil Pump Body-To-Crankcase	5/16 - 18	14 - 16
Oil Pump Cover-To-Body	5/16 - 18	14 - 16
Vibration Damper-To-Pulley	5/16 - 18	16 - 18
Water Outlet (Thermostat Housing) Bolts	5/16 - 18	8 - 10

* Torque values based on clean threads lubricated with engine oil.

GENERAL DESCRIPTION

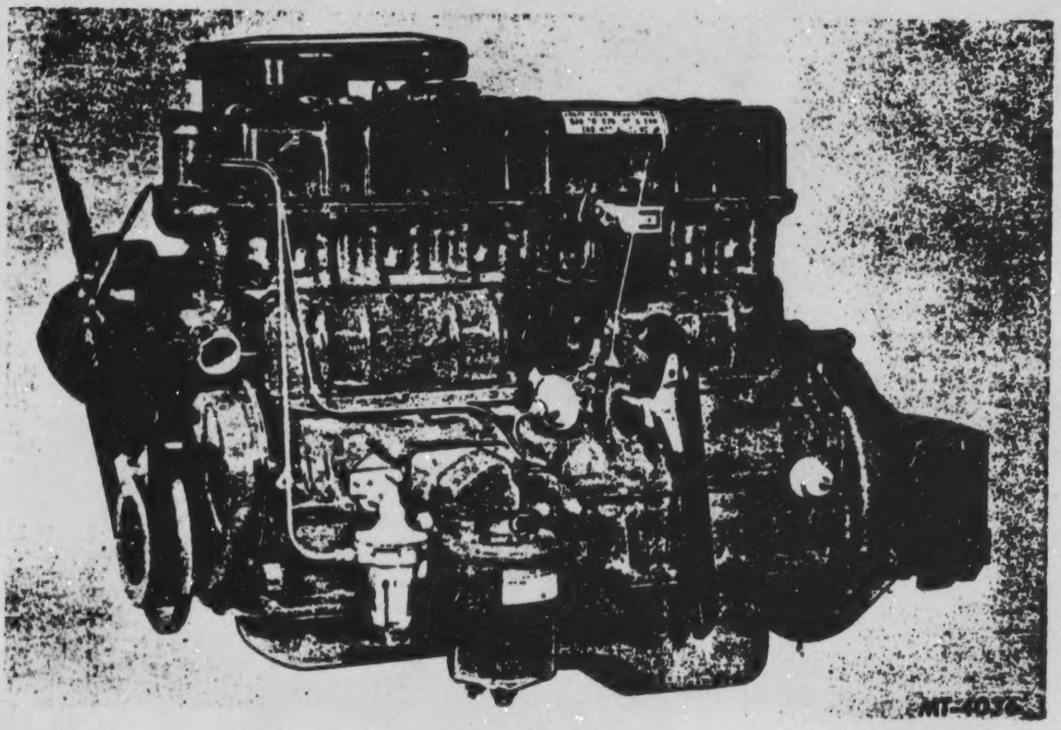

Fig. 1 - BD and BG Series Engine

The IH six cylinder BD and BG series engines are four cycle, in-line, overhead valve type engines. The cylinders are numbered from the front. Firing order is 1-5-3-6-2-4.

The cylinder block and upper crankcase are cast in one piece and is of extremely rigid construction. Full length water jackets surround each of the cylinders.

The crankshaft is drop-forged of heat-treated steel. It is counterweighted, balanced both statically and dynamically, and ground to close limits. The shaft is supported by four precision type replaceable insert main bearings. Crankshaft end thrust is controlled by thrust flanges on the third (No. 3) main bearing. A vibration damper is provided at the front end of the crankshaft on model BD-240, 264 and BG-241, 265 engines. The flywheel is bolted and doweled to the crankshaft rear flange. The engine timing mark is located on the flywheel.

The camshaft is supported by four replaceable bushing type bearings pressed into the cylinder block. Camshaft end play is controlled by a thrust flange located between the front camshaft journal and the camshaft gear.

The aluminum-alloy pistons are cam ground and have two compression rings and one oil ring. The hardened and ground piston pins are the full-floating type and are held in the pistons by snap rings.

The cylinder head is bolted to the crankcase, and a gas-tight and water-tight seal is maintained by means of a gasket. The cylinder head has wedge-shaped combustion chambers which provide more complete combustion of the fuel and air mixture. With this design combustion chamber, the valves are mounted at a 15° angle in the cylinder head. Exhaust valve seats are of alloy and are pressed into place. Valve seats lengthen the period between valve reconditioning operations. Valves and valve seats are cooled by continuous circulation of water through the cylinder head.

The intake and exhaust manifolds are bolted to each other and to the right side of the cylinder head. The intake and exhaust manifolds are each cast in one piece. Manifold gaskets are made from thin steel (without an asbestos filler).

389

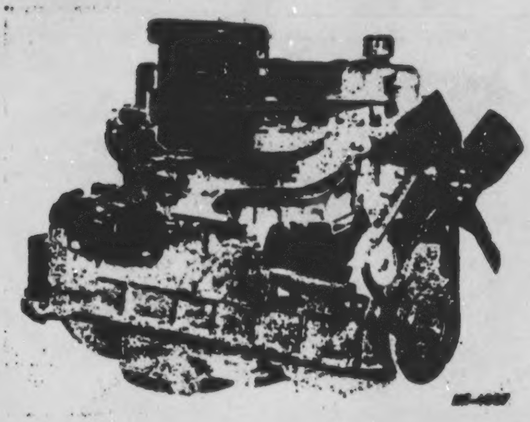

Fig. 2 - Right Front View of Engine

The generator, fan and water pump are driven by a V-type belt from a pulley mounted on the front end of the crankshaft. The distributor, mounted on the left side of the engine, is camshaft driven through the oil pump drive shaft.

Engine Lubrication System

The oil pump is mounted on the bottom of the crankcase and is driven by the camshaft. A spring-loaded relief valve in the oil filter base limits the maximum pressure in the system. A full-flow type oil filter filters all of the oil entering the engine. The filter has a relief valve which permits oil to by-pass the filter if the filter becomes clogged.

From the oil filter, oil flows into the main oil gallery, then through drilled passages to each camshaft bearing and each main bearing. Connecting rod bearings are lubricated by passages drilled from the main bearing journals to the connecting rod journals.

The rocker arm shaft receives oil through drilled passages in the block and cylinder head from the second camshaft bearing. The oil is directed through one of the rocker arm shaft supports (third from front) into the rocker arm shaft. Holes in the shaft permit lubrication of each rocker bushing and the valve and ball joint ends of the rocker arms. Oil from the rocker arms drains into the push rod chamber.

REMOVAL AND DISASSEMBLY

ENGINE REMOVAL

Engine removal procedures will vary between vehicle models and also between individual chassis because of various equipment and accessories. The procedure outlined below covers in general the engine disconnect points and lifting instructions.

1. Drain cooling system. Drain cocks are located in the lower radiator tank and on the right side of the engine.
2. Drain oil from crankcase.
3. Remove hood.
4. Disconnect ground cable from battery.
5. Remove radiator hoses. Disconnect heater hoses from engine.
6. Remove fan blade and fan belt.
7. Remove radiator and fan shroud. NOTE: On some models it is necessary to remove battery cable clipped to fan shroud.
8. Remove air cleaner. Disconnect throttle linkage and choke control cable.
9. Disconnect wiring from engine:
   a. Heat gauge sender unit.
   b. Oil gauge sender unit.
   c. Generator wires.
   d. Primary ignition wiring.
   e. Starter solenoid wires and battery cable.
   f. Engine ground strap.
10. Disconnect fuel supply line from fuel pump.
11. Disconnect exhaust pipe from manifold.

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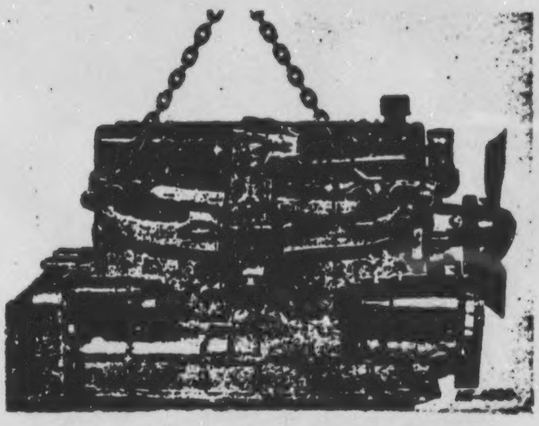


Fig. 3 - Lifting Sling Attached to Engine

12. Install lifting fixture on engine. See Fig. 3.

13. Connect hoisting equipment to lifting fixture and hoist sufficiently to support engine.

14. Remove flywheel housing cover or converter housing cover.

15. Disconnect clutch linkage or disconnect clutch slave cylinder line.

16. Disconnect engine rear mountings.

17. Support transmission and disconnect transmission from bell housing. On vehicles with automatic transmission: (1) Disconnect converter housing from adapter plate. (2) Disconnect converter from drive plate.

18. Disconnect engine front mountings from crossmember.

19. Pull engine forward sufficiently to clear clutch assembly from transmission main drive gear shaft. CAUTION: Avoid damaging clutch driven disc.

20. Tilt front of engine upward and raise engine out of chassis. Rotate engine as required to avoid contact between engine and chassis components.

21. Remove engine front mounting brackets to permit placing engine in overhaul stand.

DISASSEMBLY OF ENGINE

For ease and convenience when performing reconditioning operations, it is recommended that the engine be mounted in an overhaul stand such as SE-1434 Engine Roll-over Stand.

1. Remove oil pan, oil filter, and fuel pump to permit mounting engine in stand.

2. Mount engine in stand using support brackets and adapter plates as shown in Fig. 4. Remove lifting sling.

3. Disconnect fuel line from fuel pump and carburetor. Disconnect vacuum line from distributor and fuel pump. Remove lines from engine.

4. Remove thermostat housing and thermostat.

5. Remove carburetor.

6. Remove bolt from fan belt adjusting strap. Remove generator bracket mounting bolts and remove generator and bracket. See Fig. 5.

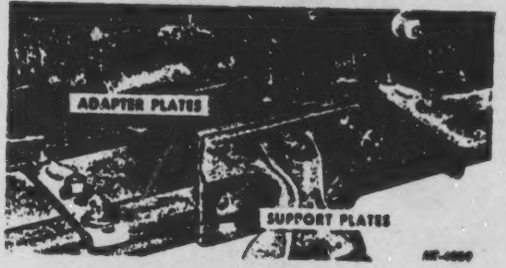


Fig. 4 - Engine Stand Supports

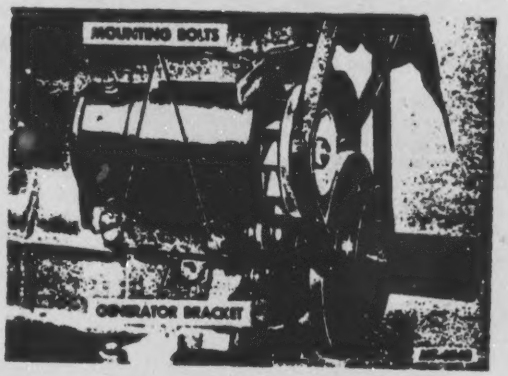


Fig. 5 - Generator Mounting Bracket

7. Remove starting motor.

8. Remove manifold mounting bolts and remove intake and exhaust manifolds as a unit. See Fig. 6.

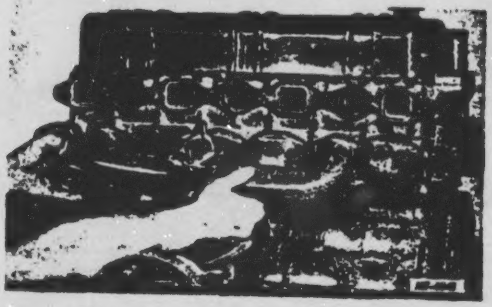


Fig. 6 - Removing Manifolds

9. Disconnect coil wires from coil and distributor.

10. Remove coil from cylinder head.

11. Disconnect wires from spark plugs. Remove distributor hold-down bolt and lift out distributor.

12. Remove oil pressure gauge sender unit.

13. Disconnect water by-pass hose from cylinder head. Remove four water pump mounting bolts and remove water pump. See Fig. 7.

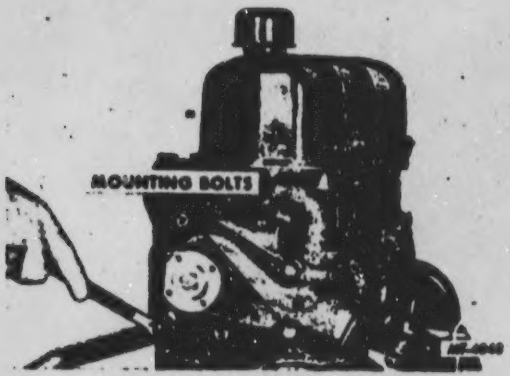


Fig. 7 - Removing Water Pump

14. Remove rocker arm cover bolts and remove cover and gasket.

15. Remove bolts from rocker arm shaft brackets and remove complete rocker arm assembly.

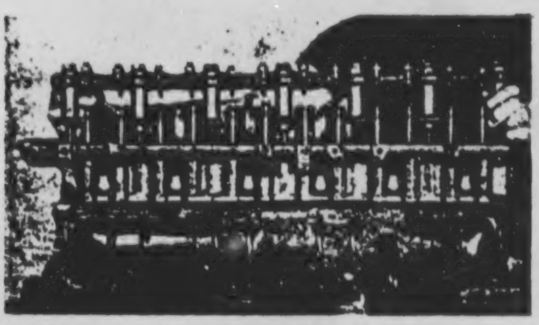


Fig. 8 - Removing Rocker Arm Assembly

16. Remove valve lifter (push) rods and keep in order of removal to assure reassembly in same location.

17. Remove remaining cylinder head bolts and remove cylinder head and gasket. See Fig. 9.

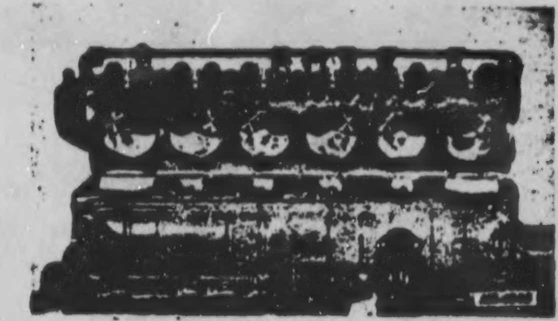


Fig. 9 - Removing Cylinder Head

18. Remove valve lifter (tappet) cover and remove lifters. Keep lifters in order of removal to assure reassembly in same location.

19. Using a ridge reamer, remove the ridge from the top of the cylinders. This should be done before removing pistons to avoid damaging pistons upon removal.

20. Rotate engine in stand. Remove oil pump mounting bolts and remove oil pump. See Fig. 10.

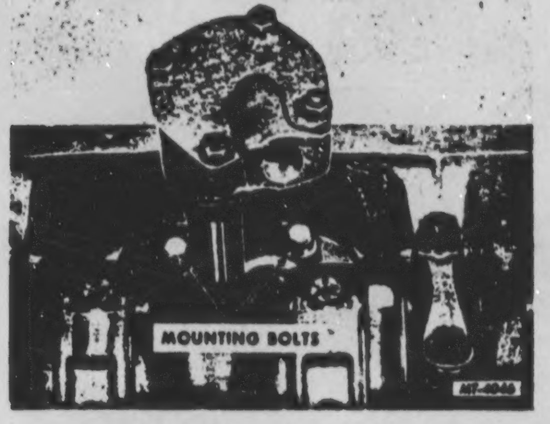


Fig. 10 - Removing Oil Pump

21. Remove connecting rod bearing caps.

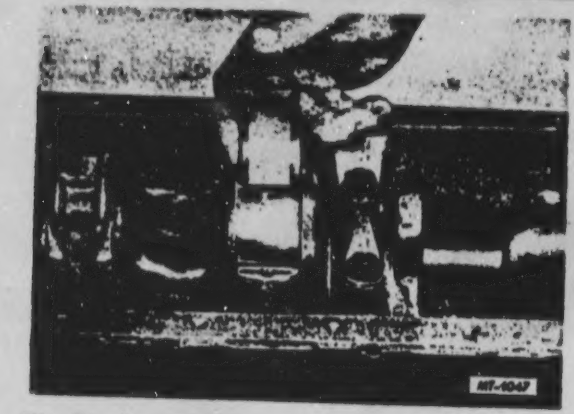


Fig. 11 - Removing Connecting Rod Bearing Caps

22. Push the connecting rod and piston assemblies from the cylinders. Reassemble the bearing caps to their respective connecting rods.

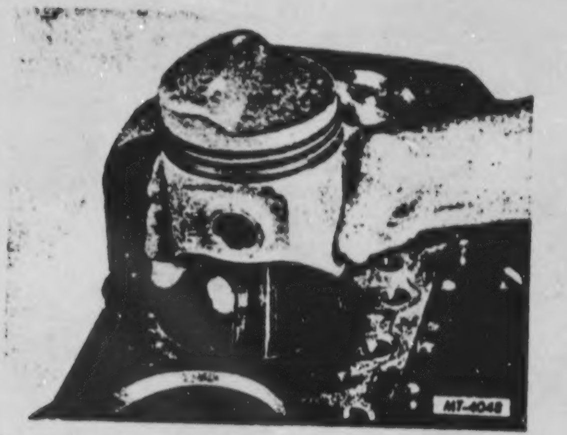


Fig. 12 - Removing Piston and Connecting Rod

23. To remove the clutch, install retaining clips between the back plate and the pressure lug or install wood blocks between the clutch fingers and the back plate. This is to hold the clutch compressed to prevent distortion of the clutch cover. Position retaining clip or wood block in place, then loosen clutch mounting bolts only enough to wedge the clip in place. Turn the flywheel one-third turn and install the second clip or block in the same manner. Follow the same procedure for the third clip or block. Remove all clutch mounting bolts and remove clutch and driven disc. See Fig. 13. Some clutches can be compressed by installing three capscrews with flat washers through the back cover and engaging the pressure plate. The three capscrews should be tightened evenly to compress clutch.

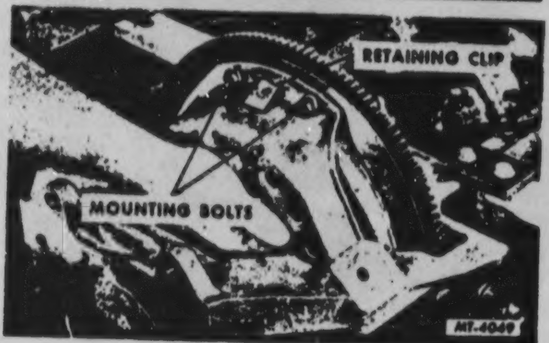


Fig. 13 - Clutch Removal

24. Remove flywheel mounting bolts. Tap flywheel with a soft hammer to remove flywheel from dowel in crankshaft flange.

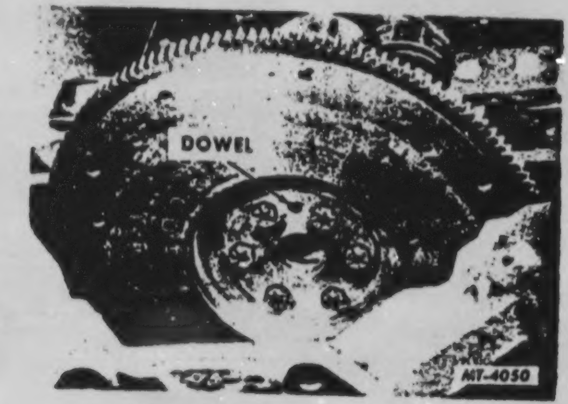


Fig. 14 - Flywheel Mounting

25. Remove crankshaft pulley nut and washer from end of crankshaft. Install puller (SE-1368) and remove pulley from crankshaft. See Fig. 15.

26. Remove hex head bolts and nuts from engine front cover (timing gear cover) and remove cover and gasket. Also remove crankshaft oil slinger. See Fig. 16.

27. Straighten lock on camshaft gear nut and remove nut. Using SE-1368 Puller, remove camshaft gear. See Fig. 17.

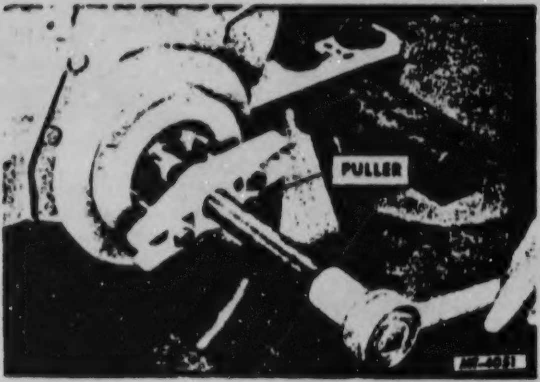


Fig. 15 - Pulling Crankshaft Pulley Using SE-1368 Puller

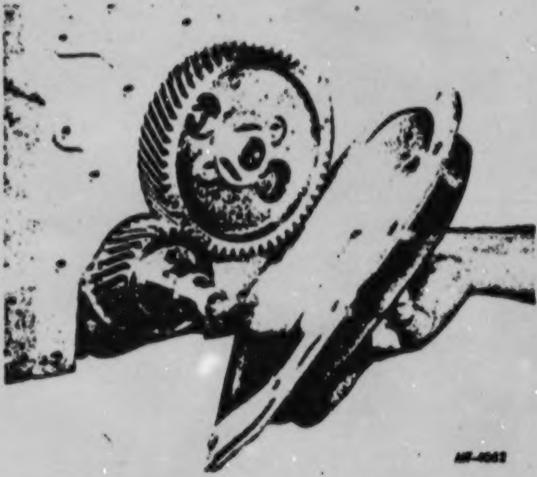


Fig. 16 - Removing Engine Front Cover

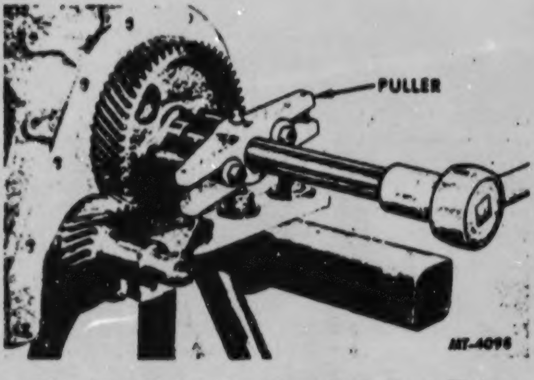


Fig. 17 - Removing Camshaft Gear Using SE-1368 Puller

28. Remove camshaft thrust flange retainer bolts and remove camshaft. To prevent nicking and damaging camshaft bearings, use remover tool SE-1800 as shown in Fig. 18.

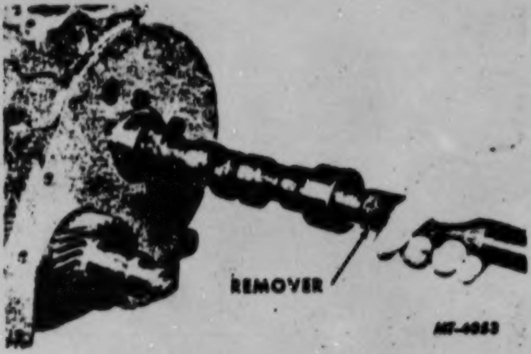


Fig. 18 - Removing Camshaft Using SE-1800 Remover Tool

NOTE: Camshaft can also be removed without removing camshaft gear from shaft. Gear can be pressed from shaft after shaft is removed.

29. Remove crankshaft gear from shaft using SE-1368 Puller. NOTE: Crankshaft gear can also be pressed from crankshaft after shaft is removed from crankcase.

30. Remove self-locking bolts and remove main bearing caps. Main bearing caps are numbered to identify their positions. The number three main bearing incorporates thrust flanges to control crankshaft end play.

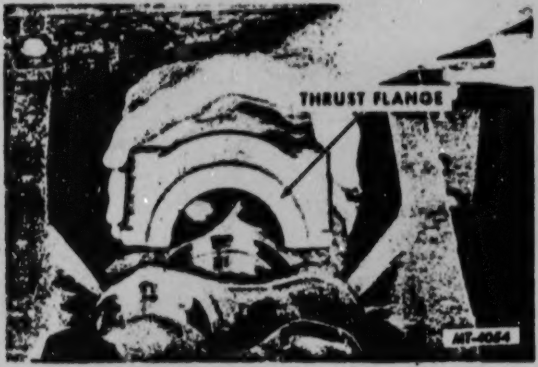


Fig. 19 - Removing Main Bearing Cap

31. Remove rear main bearing cap using SE-1719 Puller. Discard bearing cap side seals as they should be replaced whenever bearing cap is disturbed. See Fig. 20.

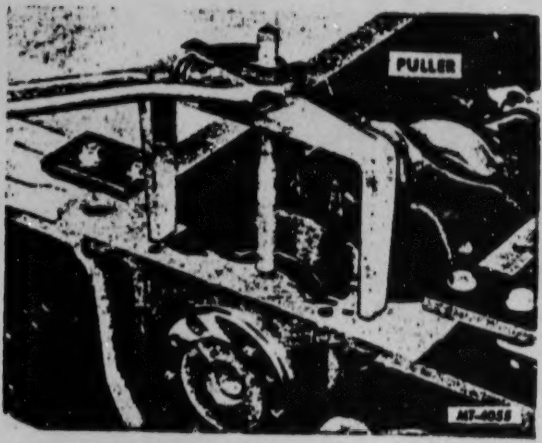


Fig. 20 - Removing Rear Main Bearing Cap with SE-1719 Puller

32. Lift crankshaft up and out of cylinder block.

33. To remove flywheel housing or adapter plate, remove six bolts, drive out the crankcase dowels, and remove the housing.

CLEANING, INSPECTION, AND RECONDITIONING

Except where indicated, no attempt has been made to prescribe a particular sequence for reconditioning the various units. Some operations can be readily performed with the engine in the chassis. The extent of service required will govern the necessity for engine or unit removal and the [illegible] of service operations.

CYLINDER BLOCK

An important phase of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machined surface of the cylinder block should be cleaned of old gasket material. Clean both inside and outside of block with steam or cleaning solvent. Remove all traces of dirty oil, sludge, scale, or carbon. The plugs which seal the oil passages should be removed and all passages thoroughly cleaned. Use SE-1567 Cleaning Brush Set.

Inspect cylinder block for cracks, breaks or stripped screw threads. Fine or hidden cracks may be located by coating the suspected areas with a mixture of light engine oil and kerosene. After wiping the area dry, immediately apply a coat of quick drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

Check top surface of cylinder block for trueness with a straight-edge. Test by attempting to insert a .005" feeler gauge ribbon between the straight-edge and the cylinder block. If this is possible, either resurface or replace the cylinder block.

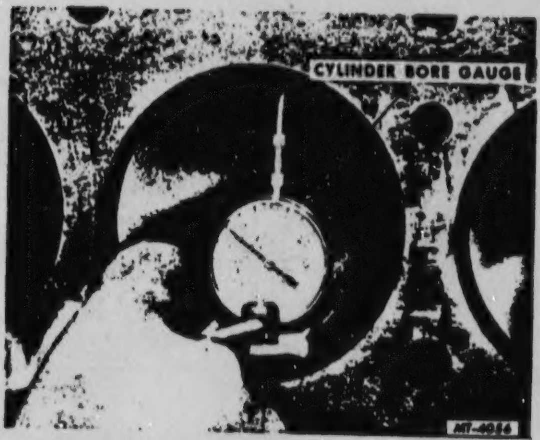


Fig. 21 - Checking Cylinder Bore Using Cylinder Bore Gauge SE-686

Each cylinder bore should be checked with a cylinder bore gauge (SE-686) to determine taper, out-of-round, or worn condition.

Measure the diameter of the cylinder bore at the top of the piston ring travel at right angles to the centerline of the crankshaft ("A" in Fig. 22). Record the measurement. Next, measure the bore at the top of the ring travel with the gauge parallel to the crankshaft ("B" in Fig. 22). The difference between the readings is the out-of-round condition at the top of the cylinder bore. Repeat this procedure at the bottom of the ring travel to check for out-of-round.

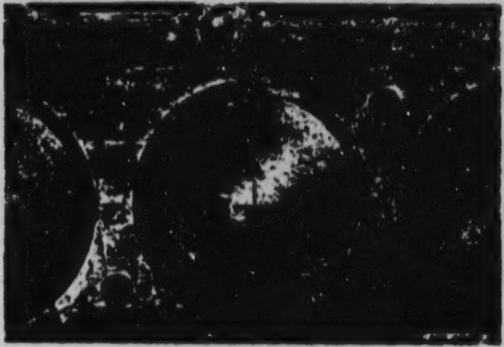


Fig. 22 - Measurements for Checking Cylinder Bore Out-of-Round

To measure cylinder taper, measure cylinder bore at the bottom of the ring travel with the gauge at right angles to the crankshaft ("B" in Fig. 23). Compare with corresponding measurement at top of ring travel ("A" in Fig. 23). Difference between measurements is the amount of cylinder taper.

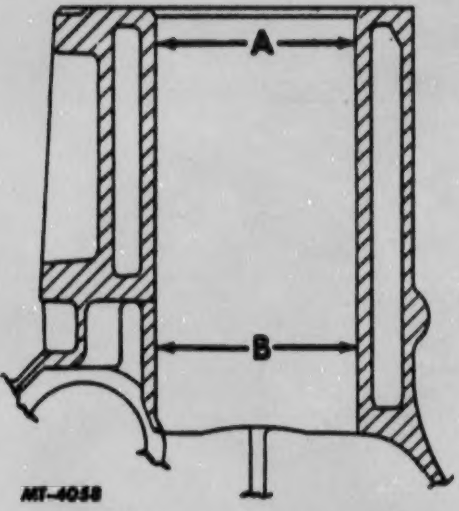


Fig. 23 - Measurements For Checking Cylinder Bore Taper

To determine cylinder wear, compare measurements at top of ring travel with cylinder bore size listed in "Specifications".

If the cylinder bore wear does not exceed the limits of .002 out-of-round and .005 taper, new standard size service piston rings will give satisfactory performance provided the piston clearance is not excessive.

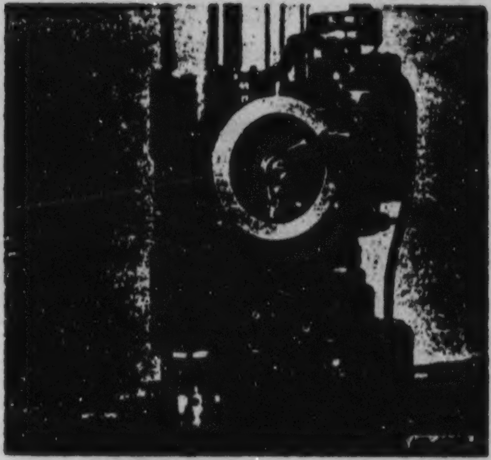


Fig. 24 - Reboring Cylinder Using Boring Bar Machine

If cylinder wear exceeds the limits, it is recommended to rebore the cylinder or cylinders to within .003" of the required oversize diameter. This will allow enough stock for the final step of honing the bores to obtain the exact clearance for the selected oversize pistons. Procedure for fitting piston is outlined below.

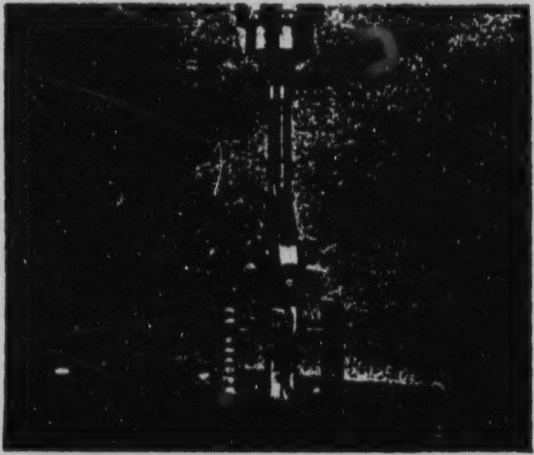


Fig. 25 - Honing Cylinder Bore Using SE-784 Honing Machine

When performing the honing operation, the hone should be stroked up and down to produce a crosshatch pattern as shown in Fig. 26. The faster the hone rotates, the faster it must be stroked up and down to produce the desired crosshatch pattern.

Fig. 26 - Crosshatch Pattern On Properly Honed Cylinder Wall.

Fitting Pistons

When the cylinders are to be honed for use of standard pistons or for final finishing after they have been rebored to within .003" of the desired size, they should be finish honed and polished. Rough stones may be used at first and fine stones for the polishing operation.

Place the hone into a cylinder bore and expand the stones until the hone can just be turned by hand. Connect a 3/4" electric drill to the hone and drive hone at drill speed while slowly moving hone up and down entire length of cylinder until hone begins to run free. During this operation, a liberal amount of honing oil should be used as a cutting fluid to keep the stones of the hone clean.

Expand the stones against the cylinder bore and repeat the honing operation until the desired bore diameter is obtained.

Occasionally during the honing operation, the cylinder bore should be thoroughly cleaned and the piston selected for the individual cylinder check for correct fit.

To check fit of pistons, use a feeler ribbon between the piston and cylinder 90° from the piston pin hole and in line with the thrust face of the piston. Apply a tension pull on scale to the feeler ribbon and check the clearance. (See "Specifications" for dimensions of ribbon size, etc.)

Insert the feeler ribbon and inverted piston into the cylinder bore. Keep the feeler ribbon straight up and down and keep the piston pin parallel with the crankshaft axis. See Fig. 27.

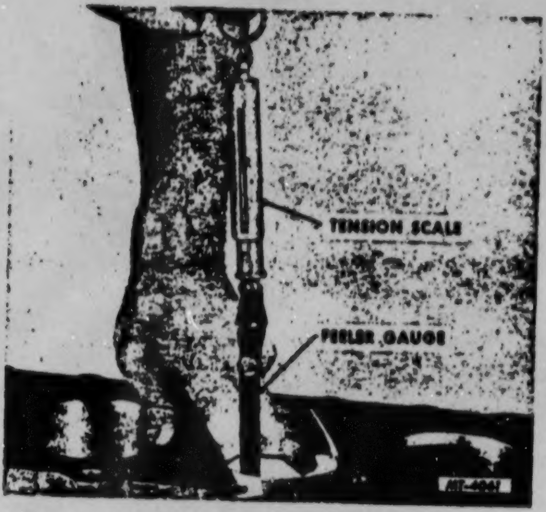


Fig. 27 - Checking Piston-To-Cylinder Wall Clearance

Pull the feeler gauge straight up and out, noting at the same time the scale reading which should be within the range given in "Specifications".

If the scale reading is greater than the maximum allowable pull, try another piston or lightly hone the cylinder to obtain the proper fit.

Should the scale reading be less than the minimum allowable pull, try another piston. If proper fit cannot be obtained, it will be necessary to rebore the cylinder to the next oversize piston.

Permanently mark the piston for the cylinder to which it has been fitted and proceed to hone cylinders and fit the remaining pistons.

It is extremely important to thoroughly clean bores after honing. If cylinders are not properly cleaned, hard abrasives remain in the engine. The abrasives rapidly wear rings, cylinder walls, and bearing surfaces. Clean cylinders thoroughly. Wipe or blow as much of the abrasive deposits from the cylinder walls as possible. Then swab out each cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean white rag shows no sign of discoloration when wiped through the cylinder bore. Never use gasoline, kerosene, or commercial solvents to clean cylinder after honing. Such solvents do not remove abrasives from the walls.

Core Plug Replacement

If necessary to remove an expansion type plug due to water leaks, drill a 1/2" hole in the center of the plug and remove by prying with a screwdriver or suitable tool. When replacing the expansion plug, position concave side of plug toward interior of cylinder block. Use SE-1725 Core Plug Installer Tool with SE-1581-1B Driver Handle and a hammer to drive plugs into position. See Fig. 28. NOTE: Coat edges of plugs with a non-hardening sealing compound prior to installation.

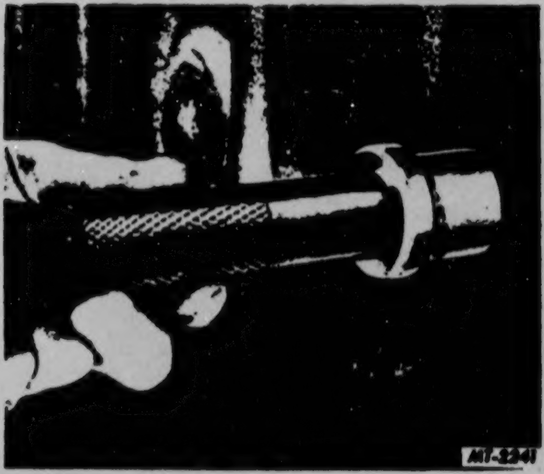


Fig. 28 - Installing Core Plug Using SE-1725 Installer

CAMSHAFT AND BEARINGS

Camshaft

Wash the camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush.

Measure the camshaft journals with a micrometer to check for wear and out-of-round condition. Refer to "Specifications" for journal dimensions. If the journals exceed .002" out-of-round, the camshaft should be replaced.

The camshaft should also be checked for alignment. This can be done be placing the camshaft end journals in "V"-blocks and checking run-out at the center journal with a dial indicator. If run-out exceeds .002", the camshaft should be replaced.

Carefully inspect cam lobes. If worn, chipped, or scored, replace the camshaft. Check the oil pump drive gear on the camshaft. If teeth are worn or damaged, the camshaft should be replaced.

Camshaft Bearings

Inspect camshaft bearings for wear and proper running clearance. See "Specifications". If limits are excessive, replace the bushings. The bushings are precision bored to provide the necessary running clearance at each of the camshaft journals. It is necessary that suitable tool equipment be used to install the bushings to eliminate the possibility of distorting or damaging the bushing shells during installation. The SE-1724 Camshaft Bushing Remover and Installer Tool consists of a set of adapters or arbors to accommodate each of the engine camshaft bushing inside diameters, a heavy pulling bar with nut and thrust bearing and a clevis device which prevents the bearing adapters from turning while the bushing is being installed. When installing the bushings, be sure oil holes are in alignment. Pull the front bearing into position first, then repeat operation progressively toward the rear. After pulling operation at one bushing is completed, leave the bushing adapter in position in that bushing to hold the pulling bar in alignment until all bushings are in place.

BUSHING ADAPTERS
YOK
HORSESHO
CAMSHAFT LOC
BUSHIN

Fig. 29 - Camshaft Bushing Remover and Installer Tool SE-1724

CRANKSHAFT AND BEARINGS

Crankshaft

Wash the crankshaft in cleaning solvent. Thoroughly clean all oil passages to remove sludge and carbon deposits.

Carefully inspect main and connecting rod bearing journals for scoring, grooving, or cracks. Use a micrometer to check journals for wear. See "Specifications" for journal sizes. If journals show wear or out-of-round in excess of .002" or taper of more than .0005" the crankshaft should be reground for undersize bearings or replaced.

The crankshaft should also be checked for run-out. To check, support the crankshaft at the front and rear main bearing journals in "V" blocks, then check run-out at front intermediate and rear intermediate (2nd and 3rd) main bearing journals. If run-out exceeds .002", the crankshaft should be replaced.

Crankshaft Bearings

The bearing inserts used in this engine are selective fit and require no line reaming on installation. The bearings are available for service in standard and undersizes for use on journals that have been reground.

If inspection reveals badly worn or scored bearings, replace the bearings. Undersize precision type bearing shells should be installed when bearing-to-crankshaft running clearances are to be reduced to compensate for wear. The installation of new bearings must be closely checked to maintain the proper clearance between the journals and bearing surface. A convenient and accurate method for checking the clearance is with the use of Plastigage as instructed under "Checking Crankshaft Bearing Clearance."

When installing precision type connecting rod or main bearings, it is important that the bearing shells fit tightly in the rod or case bore. To accomplish this, the bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled. When the assembly is drawn up tight, the bearing is compressed, assuring a positive contact between the bearing back and the bore. This increased diameter is referred to as bearing "crush", Fig. 30.

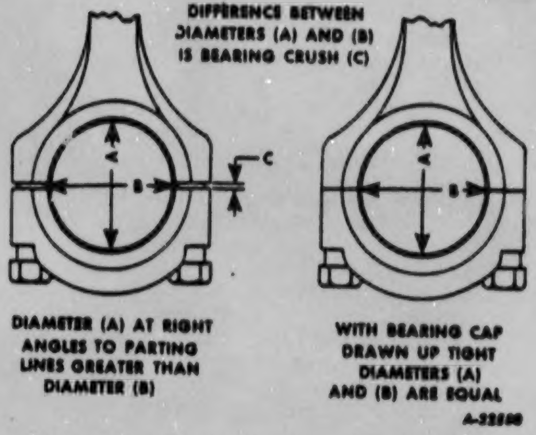

DIFFERENCE BETWEEN DIAMETERS (A) AND (B) IS BEARING CRUSH (C)
A
B
C
A
B
DIAMETER (A) AT RIGHT ANGLES TO PARTING LINES GREATER THAN DIAMETER (B)
WITH BEARING CAP DRAWN UP TIGHT DIAMETERS (A) AND (B) ARE EQUAL
A-32880

Fig. 30 - Illustrating Bearing "Crush"

To obtain proper bearing assembly with the correct "crush", care must be taken when tightening the clamping bolts to make sure they are drawn down alternately and evenly, using a tension wrench and tightening as specified.

CAUTION: Rod caps or blocks must not be filed, lapped, or reworked in any other manner in order to reduce clearance. While such practice will make a tighter fit at top and bottom, it will result in an out-of-round bore and bearing shell distortion and will alter the engineered fit of the bearing shells in their bores and destroy the specifically desired "crush".

Main and connecting rod bearings are designed with the "spread" (width across the open ends) slightly larger than the diameter of the crankcase bore or connecting rod bore into which they are assembled. For example, the width across the rod bearing not in place is approximately .030" more than when the bearing is in position. This condition is originally designed into the bearing to cause it to tend to spread outward at the parting line when "crush" load is applied by tightening bolts. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition.

This condition causes the bearing to fit snugly in the rod bore and the bearing must be "snapped" or lightly forced into its seat. Bearing spread is illustrated in Fig. 31.

BEARING SPREAD DIMENSION (MINIMUM)

	Bearing O.D. Installed	Specified Spread	Spread of Bearing Dim. "A", Fig. 31
Connecting Rod Bearings:			
BD-220, BG-220	2.500	.025	2.525
BD-240,264,BG-241,265	2.500	.030	2.530
Main Bearings:			
No's. 1, 2, 4			
BD-220, BG-220	2.942	.020	2.962
BD-240,264,BG-241,265	2.942	.030	2.972
No. 3 (Thrust)			
BD-220, BG-220	2.942	.000-.006	2.942 - 2.948
BD-240,264,BG-241,265	2.942	.002-.012	2.944 - 2.954

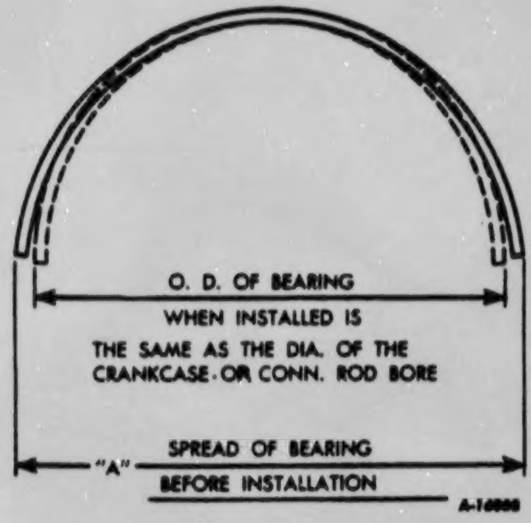

O. D. OF BEARING
WHEN INSTALLED IS
THE SAME AS THE DIA. OF THE
CRANKCASE OR CONN. ROD BORE
"A"
SPREAD OF BEARING
BEFORE INSTALLATION
A-16888

Fig. 31 - Illustrating Bearing "Spread"

Rough handling in shipment, storage and normal handling may cause bearing spread to be increased or decreased from the specified width. Bearing spread can be safely adjusted as instructed below, although care and judgment should be exercised in the process. Refer to chart for specified spread.

1. Excessive Spread. If measurement indicates that spread is excessive place thick wall

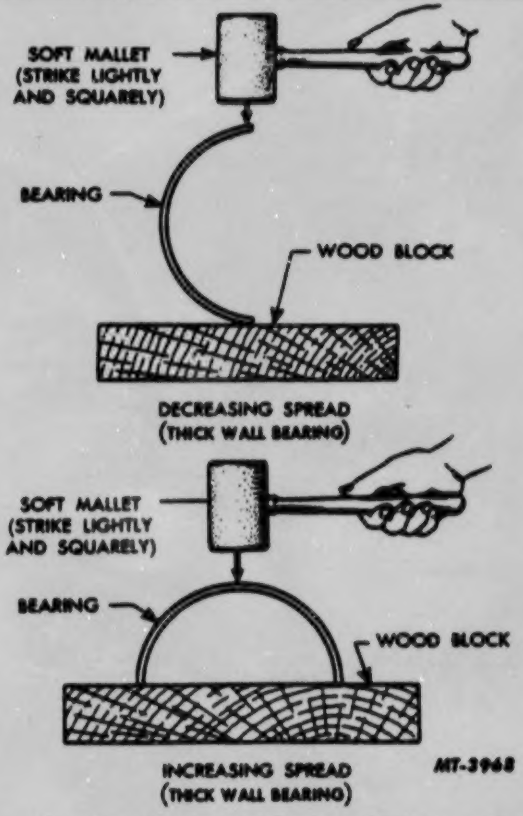

SOFT MALLET
(STRIKE LIGHTLY AND SQUARELY)
BEARING
WOOD BLOCK
DECREASING SPREAD
(THICK WALL BEARING)
SOFT MALLET
(STRIKE LIGHTLY AND SQUARELY)
BEARING
WOOD BLOCK
INCREASING SPREAD
(THICK WALL BEARING)
MT-3968

Fig. 32 - Adjusting Bearing Spread (Thick Wall Bearing)

Continued on next page

bearing (main bearing) on a wood block and strike the side lightly and squarely with a soft mallet, Fig. 32. The spread on a thin wall bearing (connecting rod bearing) may be altered with the thumb and forefingers as shown in Fig. 33. Recheck measurement and, if necessary, readjust until correct spread is obtained.

2. Insufficient Spread. If measurement indicates insufficient spread, place thick wall bearing (main bearing) on a wood block and strike the back of the bearing lightly and squarely with a soft mallet, Fig. 32. The spread of a thin wall bearing (connecting rod bearing) may be altered with the fingers and the palm of the hand, as shown in Fig. 33. Recheck the measurement and, if necessary, rejust until correct spread is obtained.

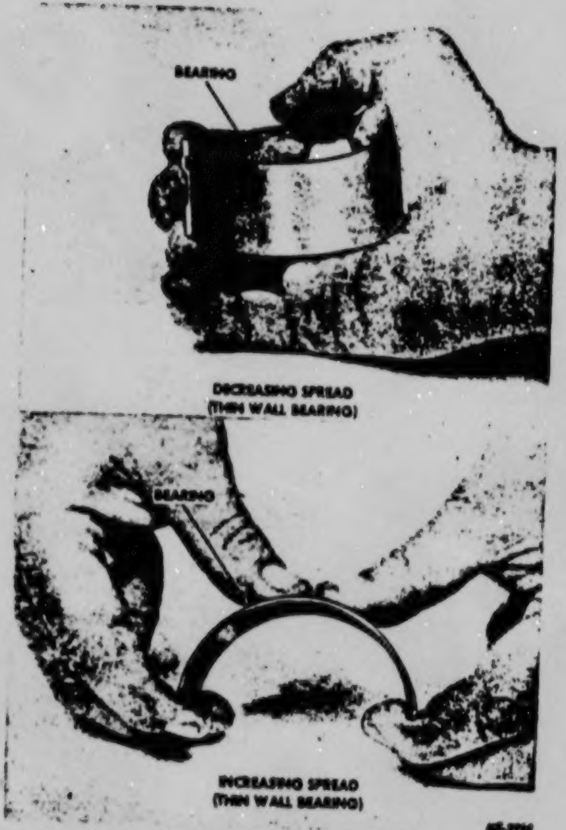


Fig. 33 - Adjusting Bearing Spread (Thin Wall Bearing)

Checking Crankshaft Bearing Clearance

Main Bearings:

To obtain an accurate reading using the Plastigage method of checking, all bearing caps must be in place and torqued to specifications.

1. Remove one bearing cap and bearing insert. Remaining caps are left tight while checking the fit of this bearing.

2. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing caps, etc.

3. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately 1/4" off center. Install bearing cap and tighten cap bolts to recommended torque.

CAUTION: Do not turn crankshaft while making check with Plastigage.

4. Remove bearing cap and insert.

5. Do not disturb Plastigage. Using the Plasti-envelope, measure the widest point of the Plastigage, Fig. 34. This reading indicates the bearing clearance in thousandths of an inch.

6. If the bearing clearance is not within specifications, the crankshaft must be reground and undersize bearings installed.

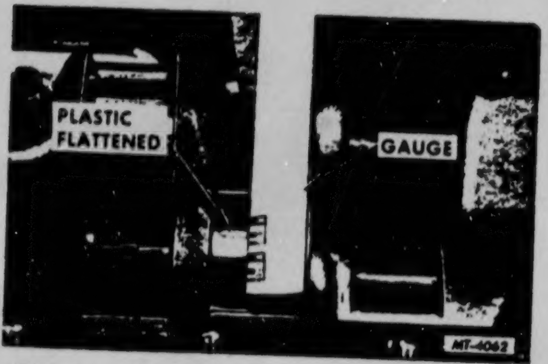


Fig. 34 - Checking Main Bearing Clearance

Connecting Rod Bearings:

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.

2. Place a piece of Plastigage on the bearing surface the full width of the bearing about 1/4" off center.

3. Install cap and tighten to recommended torque. NOTE: Do not turn crankshaft while Plastigage is in place.

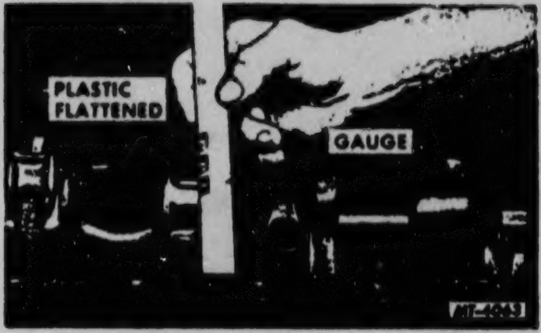


Fig. 35 - Checking Connecting Rod Bearing Clearance

4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage, Fig. 35. This reading indicates the bearing clearance in thousandths of an inch.

5. Check the connecting rod side clearance using a feeler gauge as shown in Fig. 36. Excessive clearance may require replacement of rods or shaft. The check should be made to make certain that the specified running clearance exists. Lack of clearance could indicate a damaged rod or perhaps a rod bearing out of position.

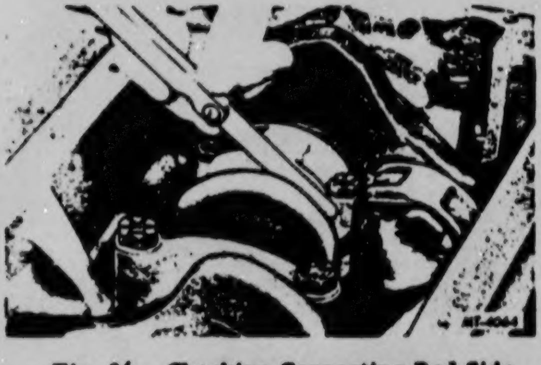


Fig. 36 - Checking Connecting Rod Side Clearance

PISTONS, PISTON PINS, PISTON RINGS, AND CONNECTING RODS

Pistons:

Remove all rings from pistons. Use a ring expander tool to expand rings, then slide them off the ends of the pistons.

Remove the piston pin retainers (snap rings) from grooves at each end of pin and push piston pin from piston and connecting rod.

After pin is removed, separate the piston from the connecting rod. Note marking on parts to assure correct reassembly.

Thoroughly clean the pistons. Use a ring groove cleaner tool or a section of piston ring with the end filed to a sharp edge to clean carbon deposits from ring grooves. Care should be taken to avoid scratching the sides of the groove.

Carbon left on the sides of the grooves may prevent a new ring from forming a good seal or could reduce the side clearance in a rectangular groove to the point where the new ring would not be free in the groove. Excessive carbon deposits on the bottom of a groove could cause the ring to protrude from the ring land. Then when the piston rocks in the cylinder, the ring may be forced to carry the piston thrust load. This will cause scuffing or scoring to occur.

Remove as much of the carbon as possible with the ring section, then immerse the pistons in cleaning solvent to soften remaining carbon deposits. CAUTION: Never use a caustic solution for cleaning aluminum pistons. Finish removing the softened carbon after removing pistons from solvent.

Never use any kind of steel brush on ring lands or piston skirts. Steel bristles will scratch piston groove sides, making a good ring-to-groove seal impossible, or they will round the outside, corners of the lands, resulting in less support for the rings and possible breakage.

After cleaning, inspect the piston for scuffing or scoring, cracks in the head or skirt areas, and for worn, bent, cracked, or broken ring lands. Fatigue failures will often show up as cracks in the area of the pin boss which is in contact with the top of the piston pin. Replace any damaged pistons. Check ring grooves for wear. Grooves should be checked at several points around their circumference because the grooves wear unevenly. Pistons should be replaced whenever ring grooves are worn excessively. See "Specifications" for specified ring side clearance.

Instructions for checking piston-to-cylinder wall clearance are given in "Fitting Pistons" under cylinder block reconditioning in this section.

Piston Pins:

Inspect piston pins for wear or etching and replace if worn excessively. If pin-to-piston or pin-to-connecting rod clearance is excessive, oversize pin can be installed. When fitting oversize piston pins to old pistons it will be necessary to ream or hone the piston pin bosses in the piston to provide the specified clearance, as shown in "Specifications". To check fit of piston pins in pistons, the pins and pistons should be at room temperature (70°F). When reaming or honing pistons for oversize pins, remember to also resize piston pin bushing in connecting rod.

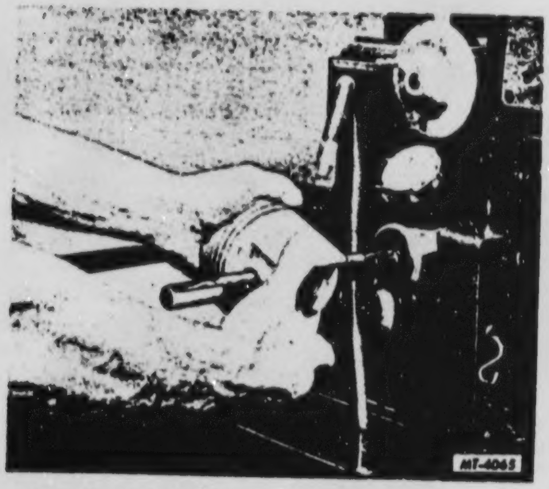


Fig. 37 - Honing Piston Pin Bosses For Oversize Pin Using SE-1811 Honing Machine

New Piston assemblies furnished for service replacement are complete with piston pins accurately fitted.

Connecting Rods:

The connecting rods should be thoroughly cleaned in cleaning solvent to remove all traces of sludge and dirt. Inspect rods carefully for cracks and defects.

The piston pin bushing should be checked for piston pin clearance. If clearance is excessive, bushing should be replaced or resized. If oversize piston pins are to be installed, ream or hone bushing to obtain correct piston pin clearance.

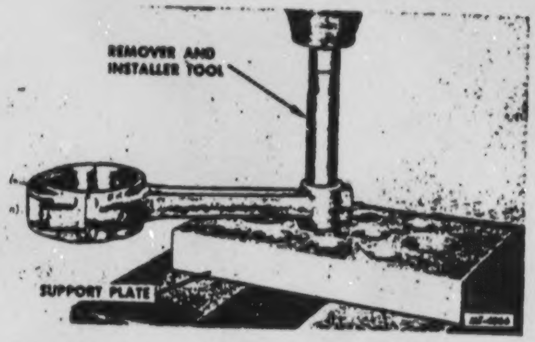


Fig. 38 - Removing Piston Pin Bushing With SE-1036-4 Remover and Installer Tool

To replace piston pin bushing, press bushing from rod using SE-1036-4 Remover and Installer Tool and SE-1033 Support Plate, as shown in Fig. 38. To install new bushing, use support plate and installer tool with proper washer, as shown in Fig. 39. Press bushing into connecting rod until washer is firmly seated on the connecting rod.

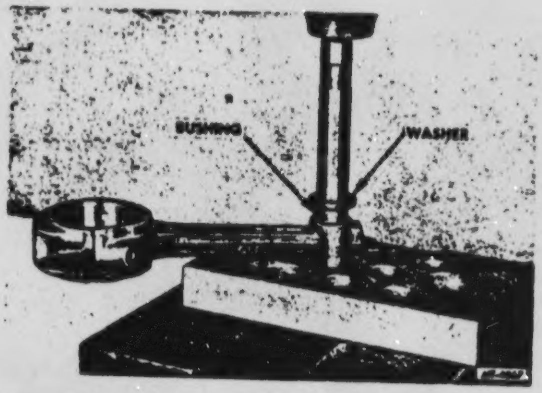


Fig. 39 - Installing Piston Pin Bushing With SE-1036-4 Remover and Installer Tool

Burnish the bushing using SE-879 Burnishing Bar and SE-1033 Support Plate, as shown in Fig. 40 or by using expansion burnishing mandrel with SE-1811 Honing Machine. This burnishing operation seats the bushing firmly in the connecting rod.

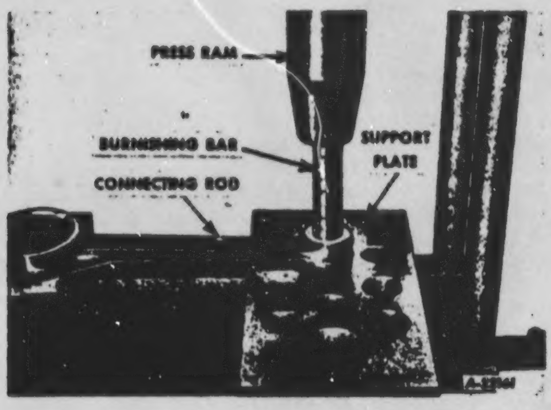


Fig. 40 - Burnishing Piston Pin Bushing

Ream or hone the piston pin bushing to provide the correct piston pin-to-bushing clearance. To check fit of piston pin in connecting rod, pin and rod should be at room temperature (70°F).

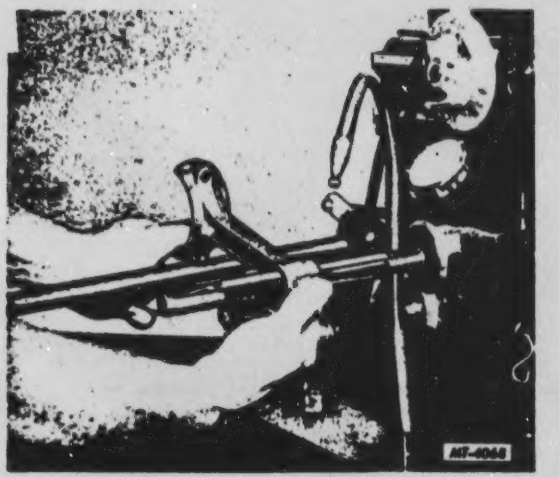


Fig. 41 - Honing Piston Pin Bushing With SE-1811 Honing Machine

When reconditioning of the connecting rod has been completed, support the rod in a vice and install the piston and piston pin. The numbered side of the rod must match up with the thrust side of the piston (camshaft side of engine). Pistons are stamped to indicate which side of piston faces front. Insert the pin into the piston, align piston with connecting rod pin bushing and push piston pin into place. Install piston pin retainers (snap rings) at each end of pin, making sure retainers seat fully and with tension in grooves.

Check alignment of connecting rod and piston assembly on an accurate connecting rod aligner such as SE-1099. See Fig. 42. Correct any misalignment.

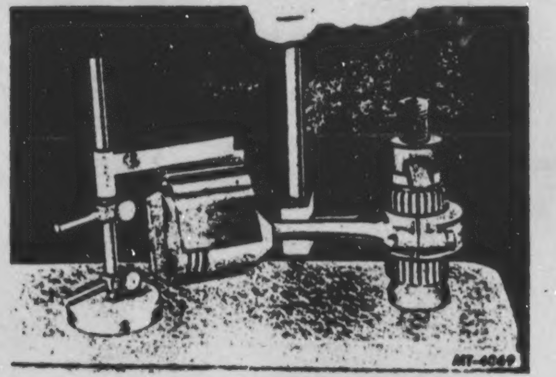


Fig. 42 - Checking Alignment of Piston and Connecting Rod Assembly Using SE-1099 Connecting Rod Aligner

The fastening of the connecting rods to the engine crankshaft is another important fundamental for mechanics to consider for engine rebuilding. How well this job is performed determines to a large extent what kind of connecting rod bearing wear will be realized. The correct torque application assures a good job.

WARNING: Do not use a power wrench for removing or installing connecting rod bolts. Such practice will cause seizure of the connecting rod bolt threads in the connecting rod.

There are a number of conditions which affect torque and the results of torque applications. The major purpose in tightening con-

Continued on next page

necting rod bolts to a specific torque is to obtain tension in the bolt (Fig. 43) which, in turn, develops a clamping load or preload that exceeds any possible loading imposed on parts due to engine rpm. (In other words connecting rod must "hang-on" to crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement or flexing of the rod cap or bolts.) At the same time torque applied must be within the capacity of parts (bolts, caps, connecting rods) to withstand these loads.

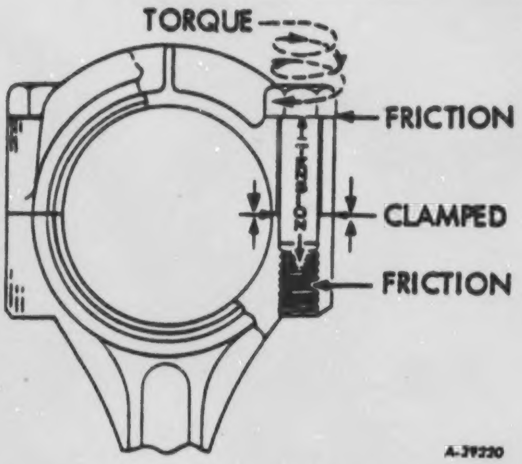


Fig. 43 - Connecting Rod Cap and Bolt Details

In tightening connecting rod bolts to their specified torque figure, a definite loading is obtained between connecting rod and cap. Especially designed bolts manufactured from selected materials permit the application of this loading without undue stretching of bolts. There is a relationship between the torque specification and clamping effect or load to be applied providing certain conditions exist. These conditions center largely around the bolt itself and are pointed out as follows:

Bolt thread condition is most important.

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort just to rotate the bolt. Then when the clamping load is first developed, or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified figure without approaching the desired bolt tension and maximum clamping effect. Under these conditions the desired torque reading is obtained but the clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage. The proper bolt tension and clamping effect can never be attained if the bolt is dry. The bolt must have a film of lubricant in the thread section and under the head to be considered lubricated. A good method of checking to determine thread condition is to turn the connecting rod bolt (lubricated) all the way into the connecting rod with the fingers. If the bolt runs in relatively free without sticking or without the need for applying more than a very light (2-4 ft. lbs.) wrench effort, the bolt is satisfactory for use. Due to the close fit of connecting rod bolts the slightest thread imperfection increases thread friction to the extent that incorrect bolt tension is likely. The threads in the rod should also be examined. Make certain that they are free of chips or hard foreign material.

Connecting rod bolts must be cleaned of all foreign matter including the anti-rust materials that may be caked in the threads. This is also true of the connecting rod thread holes. Apply light engine oil to the bolt threads to lubricate before installation. Tighten the connecting rod bolts alternately and finish tightening with the torque wrench set to the specified torque. If a bolt is inadvertently overtightened excessively, enough to stretch the bolt, it must be replaced with a new bolt. Good practice in major engine overhaul would be to use new rod bolts throughout.

The application of specific torque to any particular bolt which serves to hold or clamp two parts together should be accomplished with a torque wrench known to be accurate.

Piston Rings:

Two compression rings and one oil ring are used on each piston. The oil ring is the three-piece type, consisting of two segment (rails) and a spacer. Use rings corresponding to the size piston being used. Rings are furnished in standard and oversize diameters.

Each ring must be checked for proper ring gap. Push the ring down into the cylinder bore making sure the ring is square with the cylinder wall. Extreme care should be used during this operation. Check the space or gap between the ends of the ring with a feeler gauge, Fig. 44. See "Specifications" for proper ring gap. Oil ring spacer does not have a gap, however, oil ring rails should have gap within specified rarge.

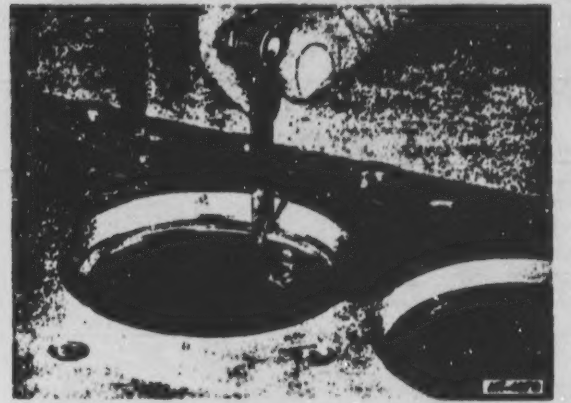


Fig. 44 - Checking Ring Gap

On compression rings, if the gap is less than the limit, try another ring for fit or dress the ends of the ring with a fine cut file until the correct clearance is obtained. The dressing of the piston ring ends is best accomplished by placing a file in a vice, then moving both ends of the piston ring (one at each face of the file) squarely across the cutting faces. Each ring should be fitted and checked in the cylinder in which it is to be used and marked accordingly.

Piston rings should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing the outer edge of the ring in the piston groove, rolling the ring entirely around the piston to make sure there is no binding and the ring is free in the groove. With a feeler gauge check the side clearance of each ring in its respective groove. See Fig. 45. See "Specifications" for proper clearance.

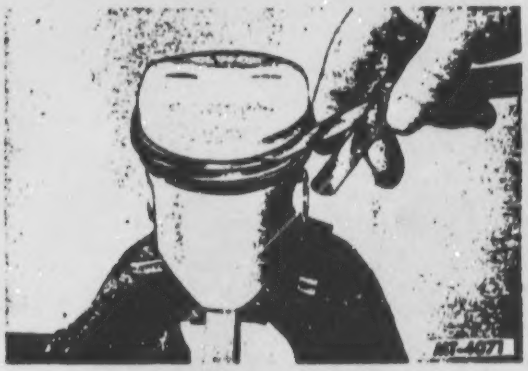


Fig. 45 - Checking Ring-To-Groove Side Clearance

Assemble the rings on pistons to which they were fitted by using a piston ring expander tool. This type of tool is recommended to avoid overexpanding and also to expand the ring to a true circle to avoid distortion. See Fig. 46.

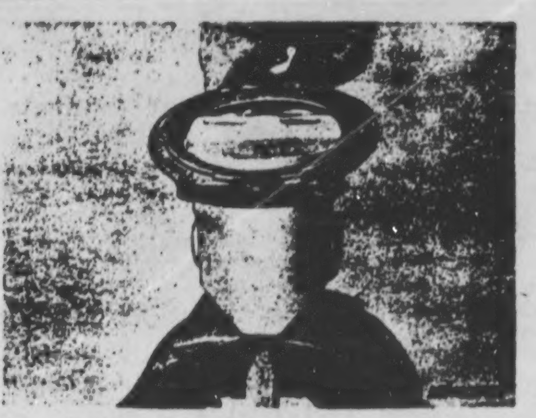


Fig. 46 - Installing Piston Ring With SE-1149 Ring Expander Tool

When installing piston rings, stagger the ring gaps. For further information refer to the instructions furnished with the service ring sets.

CYLINDER HEAD, VALVES AND RELATED PARTS

Disassembly

To protect machined surfaces of the cylinder head from damage by handling, mount the head in a holding fixture while performing service operations. Fig. 47 shows cylinder head mounting in SE-1939 Cylinder Head Holding Fixture.

NOTE: Remove valve caps from ends of exhaust valve stem and keep in order before installing head in fixture.

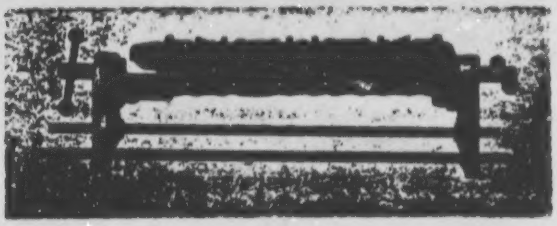


Fig. 47 - Cylinder Head Mounted in SE-1939 Holding Fixture

Before removing valves, clean the carbon deposits from the combustion chambers and valve heads with a wire brush and scraper.

To remove valves, apply a valve spring compressor and remove the valve keepers or locks, as shown in Fig. 48. Release compressor tool and remove spring retainer, spring, spring damper and oil deflector boot (intake valves). It may be necessary to strike valve ends lightly with a soft hammer to break valve keepers loose. Repeat this operation to remove all valves.

NOTE: Keep valves and their related parts together so they may be reinstalled in their respective positions.

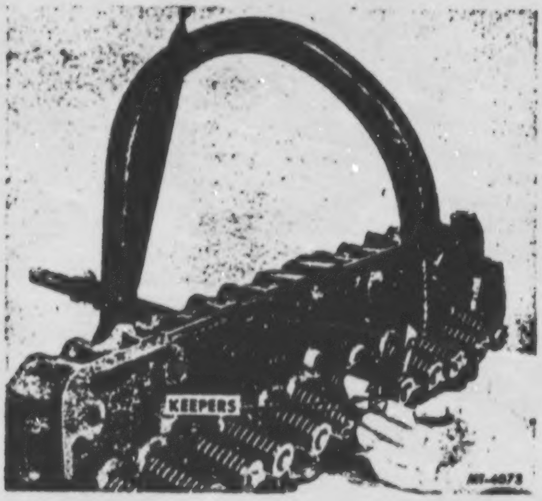


Fig. 48 - Removing Valve Keepers

Cleaning and Inspection

Clean carbon deposits from the valve ports with a wire brush and scraper. Wash the head in cleaning solvent to remove dirt and grease, then dry thoroughly. Make sure all water passages are clear and open.

The valves, springs and keepers should be cleaned by washing in a solvent. Solvent cleaning ordinarily will not remove all the deposits from the valves. Wire brushes will do this job satisfactorily, but only brass wire brushes should be used since steel brushes may scratch the surface. Such scratches are likely to cause localized stresses in an operating valve and may eventually result in fatigue fractures of the valve. For a similar reason the use of coarse emery paper should be avoided.

Examine the cylinder head for water leaks or cracks in the combustion chambers, valve ports and around valve seats. Use cylinder head test plates and gasket SE-1466-5 to check the cylinder head passages for leakage. Inspect the machined or gasket surfaces for scratches or mars which may cause leakage after assembly.

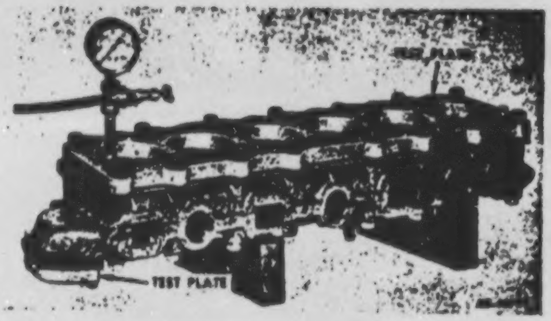


Fig. 49 - Using Cylinder Head Test Plates SE-1466-5

Check the gasket surface of the cylinder head for trueness with a straightedge. Critical points for cylinder head warpage is the section between combustion chambers. The points should be checked with a straightedge across (side-to-side) the cylinder head, and head machined only when this section is found to be more than .005" low. The cylinder head should also be checked lengthwise (front-to-rear), to determine that no section between combustion chamber is more than .005" lower than the adjoining section.

It is difficult, or often times almost impossible, to keep a cylinder gasket from blowing or burning out between cylinders, or to keep the coolant from leaking into the cylinders if the cylinder head is badly warped or if it is erroded around the water passages. This condition can be corrected by replacing the cylinder head with a new one or by grinding or milling a reasonable amount of stock off the surface of the used cylinder head. Remove only .005" material to true up the surface, otherwise contact between top of piston and head of valve may result.

Before resurfacing the cylinder head, an understanding of what happens within the engine should be considered. Milling or grinding material of the cylinder head increases the compression ratio of the engine. If milling or grinding is done within reasonable limits, the change in compression ratio is so slight that it has little effect upon operation of the engine.

407

Often there is no record kept of the number of times a cylinder head has been machined or the amount of stock removed. Under such circumstances, sufficient stock may be removed to make a noticeable change in engine performance. Increasing the compression ratio of an engine by milling several thousandths stock off the cylinder head or top of crankcase, by using a head gasket thinner than that recommended, or by using high altitude pistons in an engine operation in an area not requiring such pistons, will increase the temperature and pressure of the gases in the combustion chamber over that of the original engine, unless the changes are compensated for by changes in the grade of fuel, ignition timing, etc. Increasing the compression ratio of a specific engine generally raises the minimum octane requirement of the fuel for that engine. Consequently, if the fuel used just meets the minimum octane requirement, any increase in the compression ratio by one of the above methods will lead to detonation, loss of power, and premature engine failure. In engine installations where scuffing and scoring of cylinders and rings is a predominant cause for engine failure, it is advisable to investigate to see if significant changes have been made in compression ratio. This one factor alone may not be sufficient to cause any serious effects, but it will have an influence on other problems; and if it is combined with some other condition, the combination can result in engine failure.

Check valve spring tension using SE-1565 Spring Tester or similar tool, as shown in Fig. 50. Replace springs showing improper tension, wear, cracks or permanent sets.

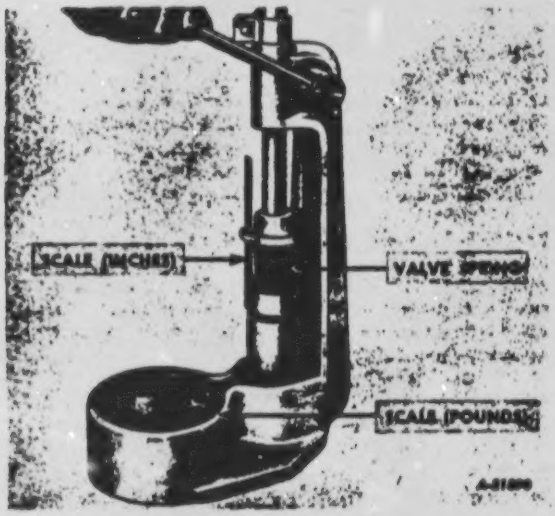


Fig. 50 - Checking Valve Spring Tension

Engine specifications specify the average spring load for the valve open plus both the compressed and the free spring length. Springs installed with higher than recommended pressures tend to overload the valve train. The use of weak springs is likely to promote valve bounce which in combination with high engine speeds is a common cause of seat pounding and valve breakage. Spring ends are designed to be flat and square to prevent lateral loads on the valve stem. Out-of-square springs place a side force on the stem and tend to promote rapid guide wear. Because of the possibility of fatigue cracks in valve springs, old springs should be replaced on the same basis as that recommended for valves which have been in service for long periods.

Inspect each valve. Discard any valves that show evidence of burned, warped or bent condition. Severely burned valves (Fig. 51) cannot be used since the metal behind the burn has probably lost its original properties.

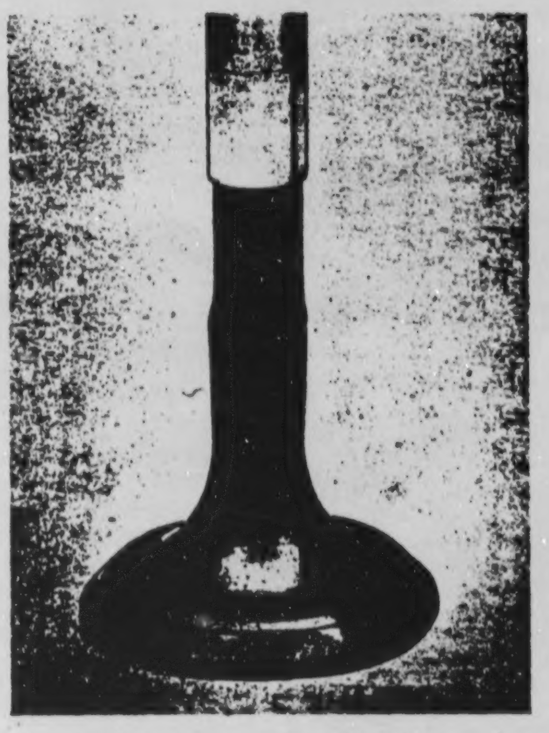


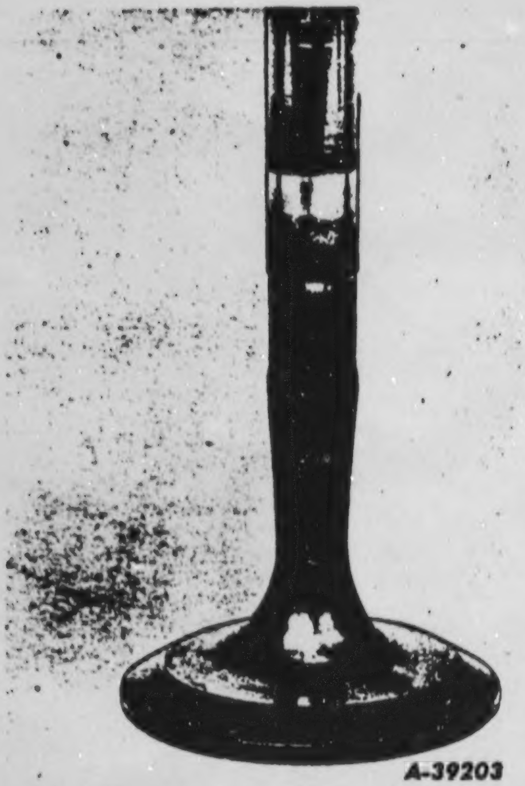
Fig. 51 - Severly Burned Valve

Valves which show indications of "necking" must also be discarded.

408

Necking is evidenced by a reduced diameter of the valve stem above the port end of the guide and is the result of hot corrosion (Fig. 52). Necked valves are susceptible to breakage - a most expensive type of failure, since the engine may be ruined when a valve head breaks off.

Badly scuffed valve stems are still another cause for rejection. Rough stems usually promote rapid guide wear. However, where there are only slight indications of scuffing at the extremities of the guide contact area and where there is no appreciable reduction in the stem diameter, such valves will continue to give satisfactory service. Worn keeper grooves or damaged valve tips are undesirable conditions and are sufficient causes for discarding a valve. Worn grooves allow cocking of the spring retainer which tends to tip the valve in the guide, increasing guide wear and, in extreme cases, causing leakage across the valve face. Similar results can be expected from the use of valves having damaged tips.



A-39203

Fig. 52 - Example of a Badly "Necked" Valve

Visual examination of the valves alone is not sufficient; certain critical dimensions must also be checked. First, the valve stem diameter is "miked" at various locations along the guide bearing area, and at each location, several measurements are made around the circumference. Valves with stems having any diameter other than given in "Specifications" should be rejected, otherwise the stem-to-guide clearance will be incorrect. Similarly, valves having margins of less than about one-half the head margin of a new valve should not be used. Such valves are particularly susceptible to face failure due to burning. In addition, the reduced depth of the margin may no longer be able to support the impact loads imposed on the valve head when the valve is closed, thereby causing the rim of the head to curl up or dish. This is called a "cupped" valve (Fig. 53).

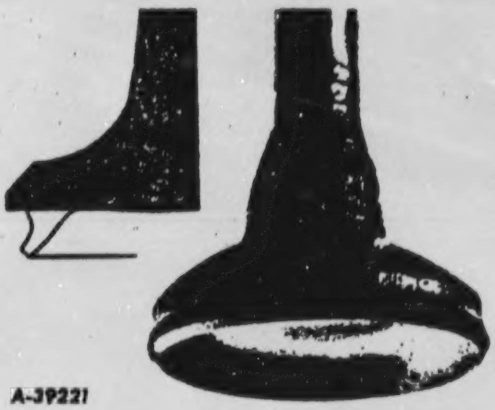


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Fig. 53 - Example of a "Cupped" Valve

One of the most important characteristics of a good valve is concentricity - the valve head and face must be concentric with the stem. If the valve is bent, the face will be eccentric with some part of the stem, or the stem will not be straight. Face eccentricity or bent heads can be checked during the refacing operation. A dial indicator gauge is particularly essential in checking for bent stems. The valve can be set up in a lathe or on V-blocks to make such measurements, but a more convenient method utilizes the special valve gauge designed for this purpose and for checking valves after refacing. An example of commercially available equipment of this type is shown in Fig. 54. With SE-1800 Valve Gauge, the valves can be checked for face or stem "run-out" quickly and accurately. Straight stems mean that all indicator readings around the stem at several points along the stem be within 0.0005" total indicator reading. Valves outside this limit have bent stems and it is recommended that they be discarded.

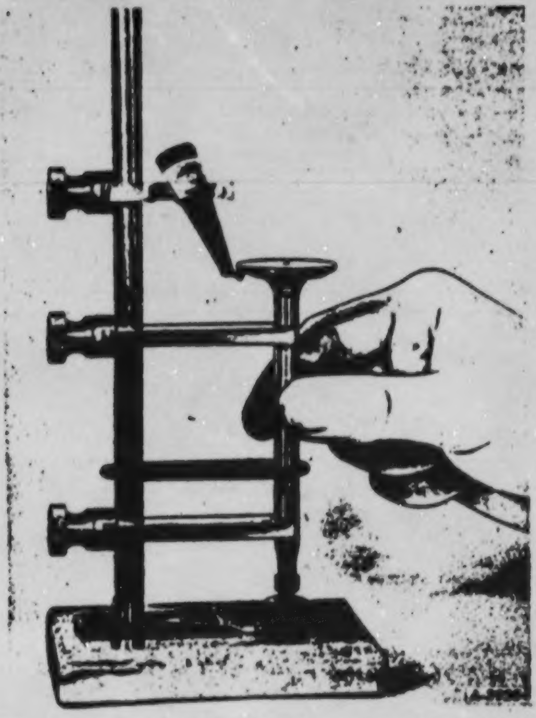

Fig. 54 - Checking Valve Stem Straightness and Face Run-Out With SE-1800 Valve Gauge.

It is good practice to replace valves which have operated for long periods of time, even though inspection indicates no evident reason for rejection. Old valves are likely to contain fatigue cracks and without the special inspection equipment required to locate such cracks, rejection is recommended because of the likelihood of valve breakage.

Inspect valve locks (keepers) for excessive wear and replace in pairs as required.

Clean valve guide bores using correct size bore cleaning tool. There are many commercially available wire brushes and scrapers (Fig. 55) that clean guides very satisfactorily.

Check valve guide bore dimensions and compare with limits listed in "Specifications" to determine condition of bores. Various instruments are available for measuring the guide bores. Fig. 56 illustrates use of SE-1826 Expanding Type Bore Gauge.

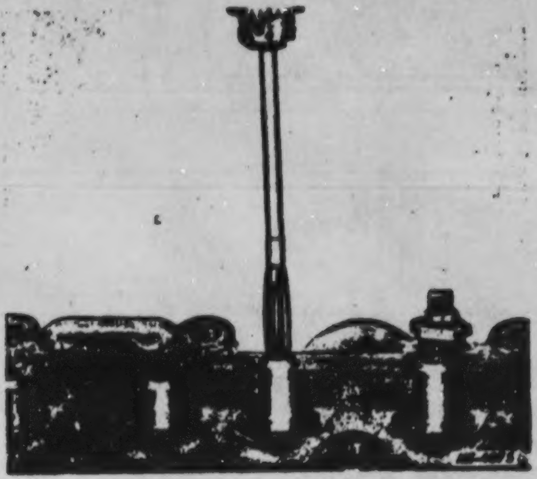

Fig. 55 - Cleaning Valve Guide Bores.

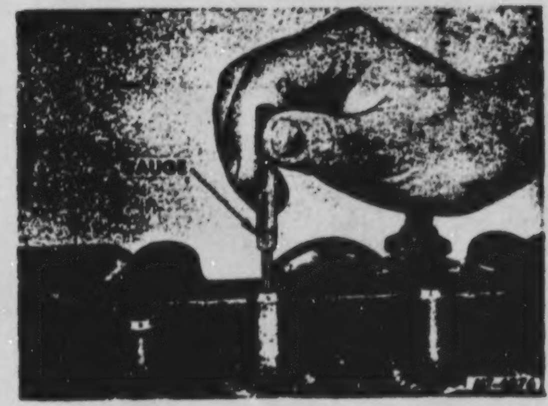

Fig. 56 - Checking Valve Guide Bore Using Gauge SE-1826.

Inspect guide bore carefully for excessive valve stem-to-guide clearance, elliptical or egg-shaped wear, and "bell-mouthing". Fig. 57 illustrates the effects of worn guides. Guides with excessive or egg-shaped wear or which are bell-mouthed more than .0005" should be replaced.

Valve Guide Replacement

When replacing valve guides, all guides must be driven from the combustion chamber side (bottom of head) through the top of the

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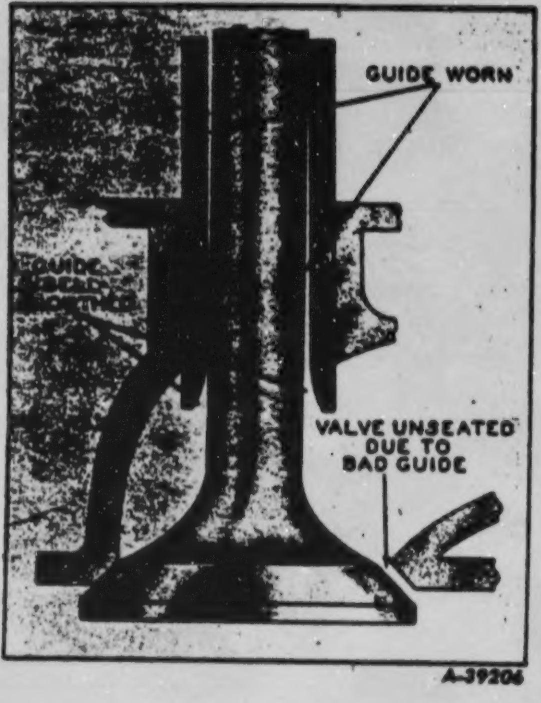

Fig. 57 - Effects of Worn Valve Guides.

head. To support the head for removing and installing valve guides, a cylinder head holding fixture can be made locally from sketch shown in Fig. 58.

Fig. 58 - Cylinder Head Holding Fixture.

Place the cylinder head holding fixture on the press bed, then position the cylinder head (bottom side up) on the fixture and locate the center moveable support adjacent to the valve guide being removed. Using valve guide remover tool SE-1722, press valve guide out of cylinder head. See Fig. 59. Repeat operation to remove other guides. Be sure to position the moveable support adjacent to the guide to be removed.

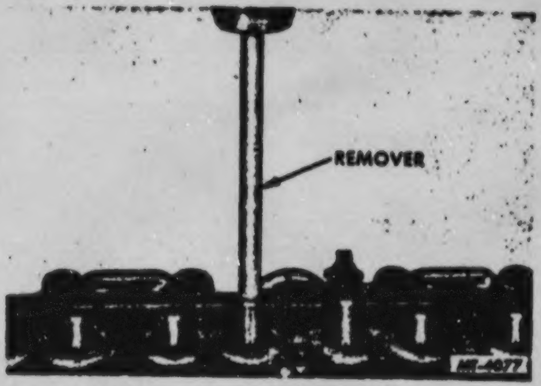

Fig. 59 - Removing Valve Guide With SE-1722 Remover Tool.

To install the guides, position the cylinder head (top side up) in the cylinder head holding fixture positioned in press. Place moveable center support of holding fixture under hole in which valve guide is to be installed.

Use SE-1943 Valve Guide Installer Tool to press guides into place. The tool is designed to install both intake and exhaust guides. This can be accomplished by adjusting the installer screw in the body to a depth equivalent to the specified height the guides are to protrude above the head. Refer to "Specifications". Fig. 60 illustrates adjusting the installer.

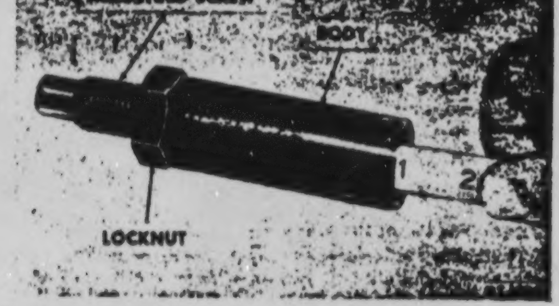

Fig. 60 - Adjusting SE-1943 Valve Guide Installer.

Press guides into guide bores of cylinder head until installer rests firmly on top of cylinder head, thus obtaining correct height above head.

NOTE: Outside diameter of valve guides must be lubricated upon installation. Use a mixture of white lead and engine oil. Clean away any excess lubricant after valve guide is installed.

Replacement guides are designed to give proper valve stem-to-guide clearance when installed in the cylinder head. Reaming is not required, but care should be taken to see that ends of guides are not burred during installation.

Core Plug Replacement

Cylinder head core plugs should not be disturbed unless evidence of leakage exists. Replace plugs as inspection warrants. The plugs can be removed by drilling a small hole in the center of the plug and prying the plug from its bore. To install a new plug, coat the outer edge with non-hardening sealer and using SE-1725 Core Plug Installer and SE-1581-1B Drive Handle, drive plug flush with bottom edge of chamfer in cylinder head. See Fig. 61.

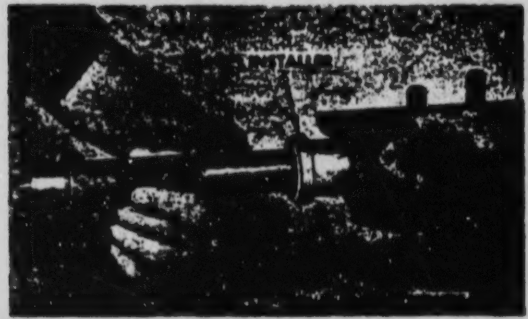

Fig. 61 - Installing Core Plug.

Valve Seat Insert Replacement

When reconditioning valves, the valve seat inserts should be inspected. If inserts are cracked, pitted, excessively worn or in other unsatisfactory condition, they must be replaced. Good practice requires that the insert counterbore in the cylinder head be machined prior to installation of the insert. Cutters are available to dress both the bottom and circumferential surfaces, but regardless of the method, the bottom of the counterbore must be square to assure good seating of the insert. Use valve seat insert tools SE-1797 or SE-1805.

Thoroughly clean the valve seat counterbore. Measure the outside diameter of the insert with a micrometer and select the correct size counterbore cutter. Cutters are made to cut counterbores slightly smaller than the O.D. of the insert to provide the correct press fit of the insert to the counterbore. Run the cutter down until it bottoms in the original counterbore. Clean all chips and particles from counterbores.

Chill inserts to be installed with dry ice for about ten minutes. Place chilled insert in counterbore--face side up. Using installer tool from counterbore tool set, drive insert into counterbore. Peen insert securely into place. Use peening equipment furnished with tool set or a dull-pointed chisel 1/4" wide may be used to satisfactorily peen cylinder head metal over the outer edge of the insert. Check valve seat for concentricity with valve guide.

Refacing Valves

Valves that are pitted can be refaced to the proper angle on a valve refacing machine. All valves having bent, worn, or seriously pitted stems should be replaced.

Good valve refacing equipment is available and nearly all present day refacing machines, when in proper adjustment, will grind the valve face within allowable run-out specifications. They give accurate control of the face angle and produce a smooth finish on the valve face.

Regardless of the equipment used, the face angle must be set accurately to the engine specifications. It is desirable to check the face angle occasionally to assure proper adjustment of the machine and the grinding wheel must be dressed at frequent intervals to maintain the correct surface finish. In the refacing operation, only the removal of sufficient metal to produce a continuously bright surface is required. The use of fine cuts only is essential in the removal of metal from the face to prevent overheating, the possibility of bending the valve, or removal of excessive metal which would reduce the margin beyond acceptable limits.

The amount of grinding necessary to true the valve face is an indication of warpage of the valve head from the center line of the valve

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stem. Since refacing machines rotate the valve as it is ground, inspection for bent heads is an easy matter. The first contact of the wheel with the valve face will give the experienced operator an immediate indication of the degree of face eccentricity and will allow a determination of whether the refaced valve will have too narrow a margin at one point or at all points around the head, Fig. 62. Valves with bent stems or warped heads should obviously not be used.

When the warped head of a valve is refaced, a knife edge will be ground on part or all of the valve head because of the amount of metal which must be removed to completely reface. Maximum heaviness in a valve head is required for strength and to provide as large an area as possible for heat dissipation. Knife-edged valves lead to breakage and warpage. See Fig. 62. Replace any valve that can not be satisfactorily refaced with a definite margin maintained.

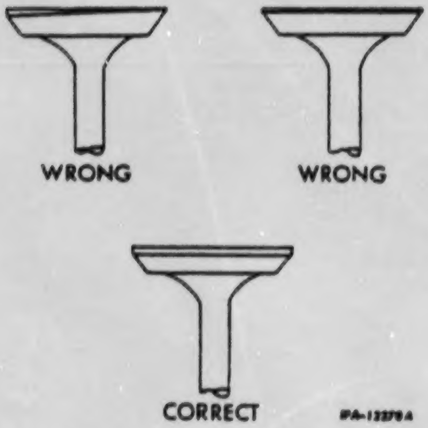

Fig. 62 - Examples of Improperly Refaced Valves

Valve Refacing Procedure:

1. Set the valve refacing machine (Fig.63) to the specified angle and dress the grinding stone.

2. Insert a valve in the chuck and take a light cut across its face. Repeat light grinding cuts until a true face of even width is obtained around the valve. Avoid taking heavy grinding cuts as this overheats the valve head producing an unsatisfactory face and damages the grinding stone. Avoid passing the stone beyond the valve face as this causes ridging and grooving of the stone. Reject all valves which produce uneven faces or which grind down to a thin edge. Warpage not apparent by visual inspection will be clearly seen as valve is ground. Do not remove more material than is necessary to remove the burned or pitted areas and true-up the valve face. Redress the stone frequently to maintain a smooth even surface and the correct face angle.

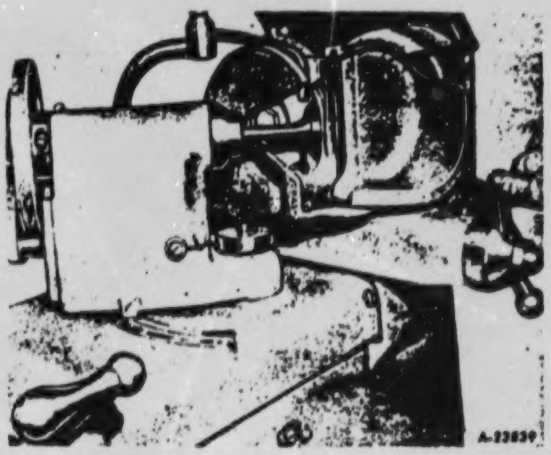

Fig. 63 - Grinding Valve Face Angle

3. After refacing each valve, inspect the end of the stem. If wear is noticeable, reface the end of the stem. Do not remove excessive material. Rechamfer if necessary.

Refacing Valve Seats

The primary purpose of a valve seat is to seal the combustion chamber against pressure losses and to provide a path to dissipate the heat accumulated in the valve head so as to prevent burning of the seat and warping of the valve head.

The location of the valve seat on the valve face and its width controls the amount of valve head that protrudes into the combustion chamber. It is obvious that the greater the exposure within the combustion chamber, the higher the valve temperature; or in other words, the more heat it will collect. High valve temperature and poor heat dissipation also produce excessive valve stem temperatures. This will hasten the accumulation of carbon on the stems, causing them to stick in the guides.

The location of the area of contact between the valve and the seat is a very important factor in securing maximum valve life. The correct position of the valve face on the seat is shown in Fig. 64. Seating the valve as shown in Fig. 65 is undesirable, since the sharp edge of the seat does not contact the valve face. This sharp edge tends to break off face deposits which may lead to valve failure. Similarly, the location of the upper line of contact well below the top of the valve face as shown in Fig. 66 is also undesirable because a large overhang prevents rapid cooling of the outer edge of the valve.

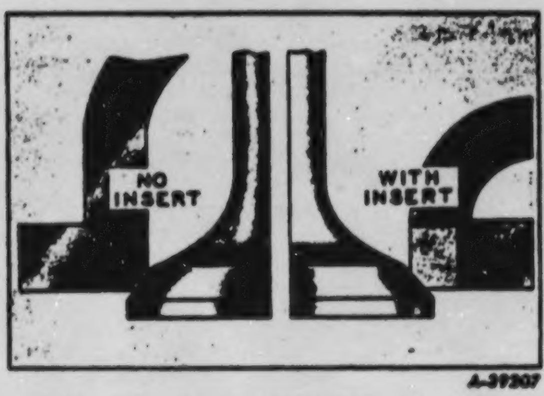

Fig. 64 - Correct Valve Seat Location.

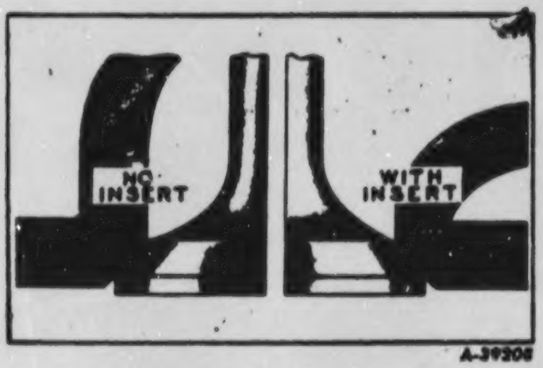

Fig. 65 - Valve Seat Too Deep in Cylinder Head.

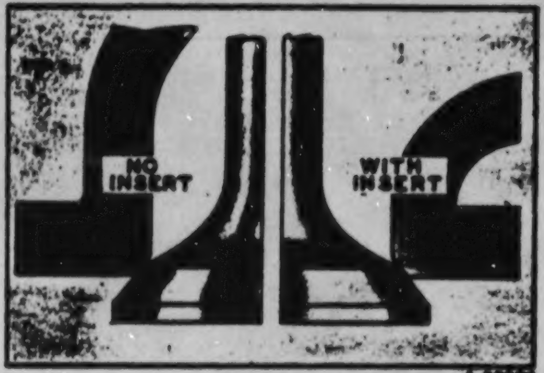

Fig. 66 - Valve Protrudes Too Far.

The valve seats must be ground true to the specified angle and width shown in "Specifications". The width of the exhaust seat should range between the average and maximum specifications and the intake seats should range between the average and minimum specifications. The intake seats may be narrower than the exhaust seats because they are usually larger in diameter. This provides a total seat area approximately equal to the similar exhaust valve with the wider seat. Also, the less severe heat conditions do not require as large a seat area for heat dissipation purposes.

Correct width can be obtained by using narrowing stones to bring the seats to the desired dimensions. Seat width is important in maintaining a good seat; too wide a seat may result in too low a valve closing pressure to prevent the formation of face or seat deposits, and too narrow a seat may cause rapid seat or face

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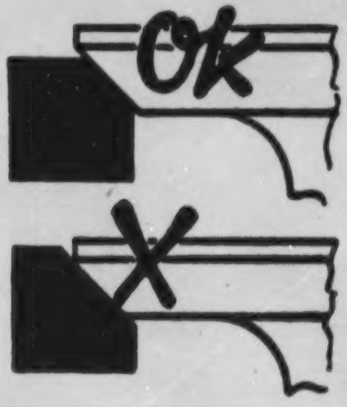

Fig. 67 - Valve Seat Width Should Conform to Specifications and Center on Valve Face.

wear or grooving. Rapid face wear or grooving, in turn, results in a greater than normal loss of valve lash. Excessive loss of valve lash (tappet clearance) may cause the valve to hold open at high engine speeds and thus lead to early failure.

Seat Refacing Procedure:

1. Remove all carbon, scale, and oil before attempting to reface valve seats. The grinding stone, when placed against an oily seat, will become fouled, and uneven grinding will occur.

2. Dress the stone to the correct angle. Lightly lubricate and install the pilot of the correct size into the valve guide bore.

NOTE: Before installing the pilot, be certain that the valve guides are perfectly clean and meet the engine specifications. This is important; otherwise, an eccentric seat will be cut.

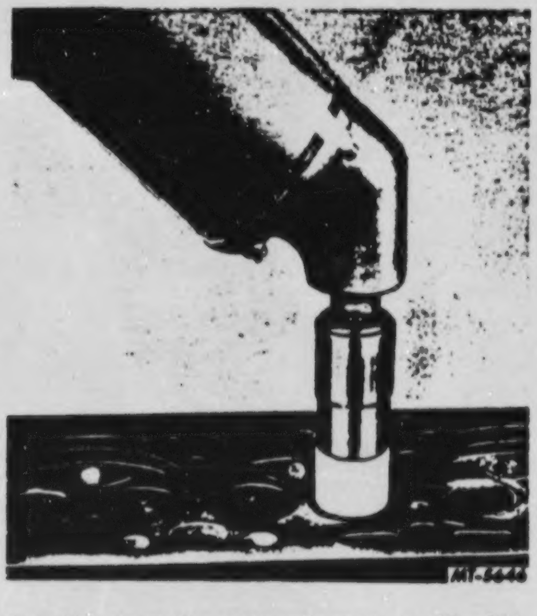

Fig. 68 - Grinding Valve Seat Using SE-1631 Seat Grinding Equipment.

3. Lower the grinder head over the pilot shank until the stone just clears the valve seat. Turn on the power and very gently allow the stone to contact the valve seat. Very little pressure other than the normal weight of the stone should be used. Sudden hard pressure can cause cocking of the pilot in the guide and result in eccentric grinding. Raise the stone frequently from the valve seat to prevent overheating and to clear away grinding dust. Grind the seat sufficiently to provide an even, smooth surface.

4. After grinding the seats, it may be found that the seats are considerably wider than the width recommended in the "Specifications". Valve seats that are too wide may be narrowed by grinding the top and/or bottom edge of the seat to reduce the width (Fig. 69). The finished valve seat should contact the approximate center of valve face. To reduce the height of the valve seat use a 15° angle stone and to raise the valve seat use a 45° angle stone.

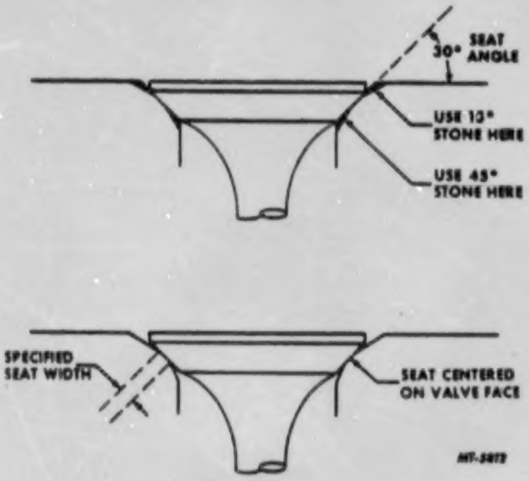

Fig. 69 - Narrowing Valve Seat Widths.

5. Check the valve seat for concentricity or run-out. Use dial indicator as shown in Fig. 70. Seat run-out should not exceed limits shown in "Specifications".

6. Check valve face contact using Prussian Blue. Spread an extremely thin film of this blue on the valve face and insert the valve into its guide. With pressure on the exact center of the valve head, make a quarter turn rotation in the seat. Remove the valve and inspect the impression made upon the seat by the transfer of blueing, and upon the valve face by the removal

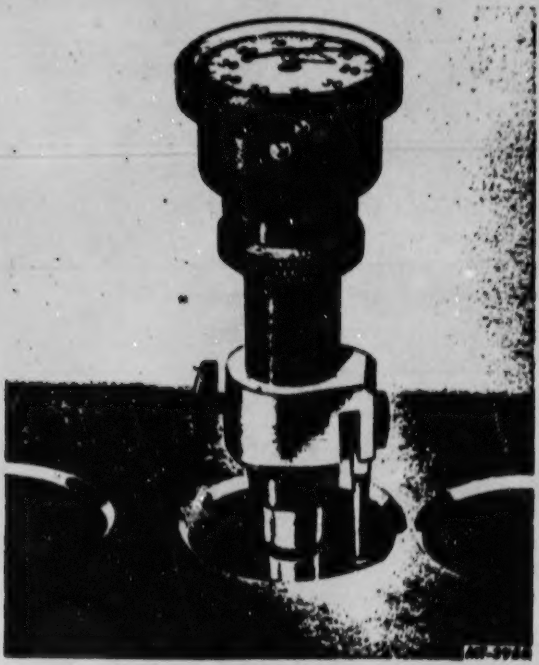

Fig. 70 - Checking Seat Run-Out.

of blueing. Check several times to guarantee that no error was made. The finished seat face should contact the approximate center of the valve face. If a full seat-width contact around the entire circle of seated valve is not shown, the angles do not match. It will then be necessary to redress the valve seat grinding stones, changing the angle sufficiently to correct the error. The correction should be made on the valve seat and not on the valve.

One of the principal difficulties experienced in reconditioning the cylinder head assembly is obtaining identical angles on the valve seat and valve face. The grinding stones on both the valve refacing machine and the valve seat grinder should be dressed before starting a reconditioning job. It will be necessary to grind one seat and valve and make a check with a light tint of Prussian Blue to determine how closely the angle of the seat and valve will match. If a full seat width contact around the entire circle of seated valve is not shown, the angles do not match. It will then be necessary to redress the valve seat grinding stone, changing the angle sufficiently to correct the error. The correction should be made on the valve seat and not on the valve. No more material should be removed from the valve face than is necessary to true it up and remove the burned or pitted portion. New valves should not be refaced but should be checked for trueness. When a satisfactory match of valve seat and valve face angles has been obtained, the adjustment of both the valve refacer and the seat grinder should be locked in position to eliminate this trial and error method for the other valves and seats.

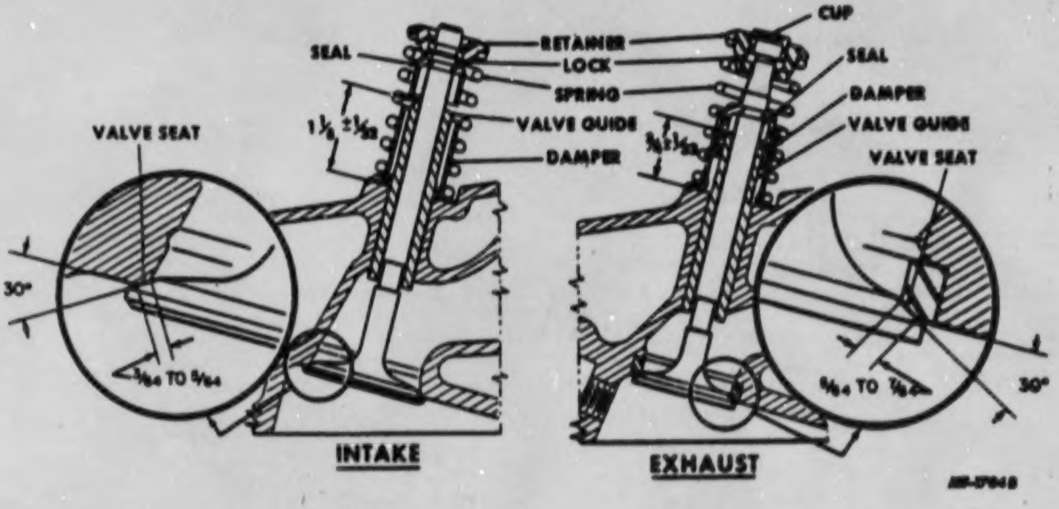

Fig. 71 - Sectional View of Valves and Related Parts.

Hand lapping of valves is not necessary for valves and seats reconditioned as described here and use of lapping compound is not recommended. A poor grind job cannot be corrected by lapping. A near perfect seat often times is destroyed by attempting to lap the valves to their seats.

Exhaust Valve Rotators

The exhaust valve "Slo-Roto" caps require special attention when exhaust valves are reconditioned. The rotating valve (Slo-Roto type as illustrated in Fig. 72) is used to reduce exhaust valve burning by shearing off any deposits which might collect on the valve seat. However, to insure this valve rotation and allow for valve expansion, the valve stem face to valve cap clearance and the valve to rocker arm clearance must be maintained.

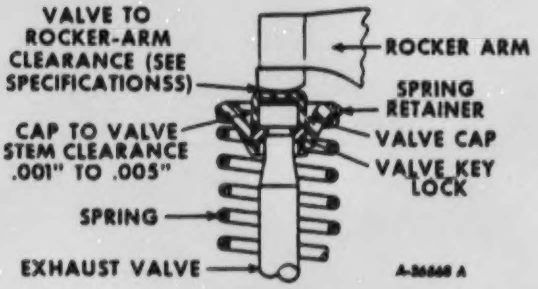
VALVE TO ROCKER-ARM CLEARANCE (SEE SPECIFICATIONSS)
ROCKER ARM
SPRING RETAINER
CAP TO VALVE STEM CLEARANCE .001" TO .005"
VALVE CAP
VALVE KEY LOCK
SPRING
EXHAUST VALVE

Fig. 72 - Cross-Sectional View of "Slo-Roto" Valve Cap.

To see why this is necessary the principle of operation should be understood. In brief, the valves rotate while operating because they are free from spring tension for a split second during each up and down cycle. When camshaft rotation reduces valve to rocker arm clearance to zero, the cap on the valve stem causes the valve keys to lower the spring retainer. This small movement relieves the load of the valve spring from the valve before the valve itself is lowered from its seat and permits the valve to turn free. To accomplish this the specified clearance between the face of the valve stem and the underside of the cap must be maintained. This is the distance the spring retainer is lowered before the valve is moved. The valve rotating motion is caused by vibration of the valve, the flow of exhaust gases around the valve head, and a slight rotating motion imparted by the valve spring. Fig. 73 illustrates the proper method for checking cap clearance with valve installed. Fig. 74 illustrates the method of checking cap clearance with valve removed.

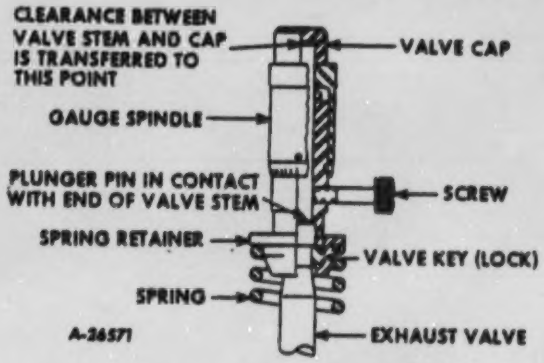
CLEARANCE BETWEEN VALVE STEM AND CAP IS TRANSFERRED TO THIS POINT
VALVE CAP
GAUGE SPINDLE
PLUNGER PIN IN CONTACT WITH END OF VALVE STEM
SCREW
SPRING RETAINER
VALVE KEY (LOCK)
SPRING
A-26571
EXHAUST VALVE

Fig. 73 - Using SE-1733 Valve Gauge for Checking Cap Clearance with Valve Installed.

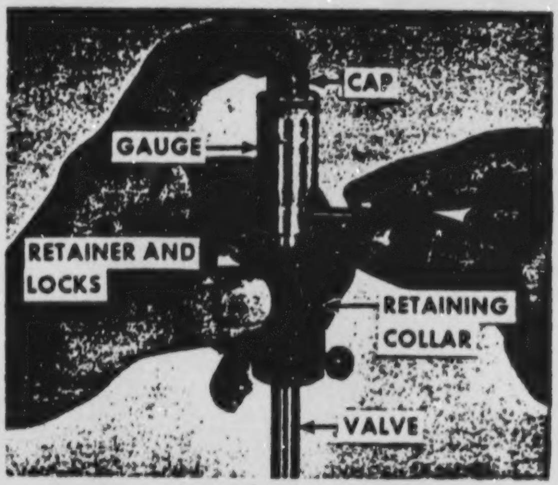
CAP
GAUGE
RETAINER AND LOCKS
RETAINING COLLAR
VALVE

Fig. 74 - Using SE-1733 Valve Gauge for Checking Cap Clearance with Valve Removed.

Since maximum service life and efficiency of rotating exhaust valves is dependent on the maintenance of the correct cap clearance, the adjustment becomes most important. In service this clearance normally increases because of wear caused by impact of the half-moon keys against the shoulder on the valve stem. As the cap clearance increases so also does the rate of wear increase because of harder impact from longer key travel. To decrease cap clearance remove sufficient material from lower face of skirt of cap to establish proper limits. When reground or new valves are installed and it is necessary to increase cap clearance it will be necessary to grind the valve stem face. If the valves have been in operation over an extended period the valve keys may show signs of wear at the point of contact with the valve stem. As long as the correct clearance (see "Specifications") is maintained, this wear is not harmful.

Valve keys must be installed with the wear facing the same direction (Fig. 75). This will eliminate cocking of the spring retainer. However, both valve keys may be reversed (worn side turned down) to utilize the unworn face of the keys provided the specified clearance is maintained.

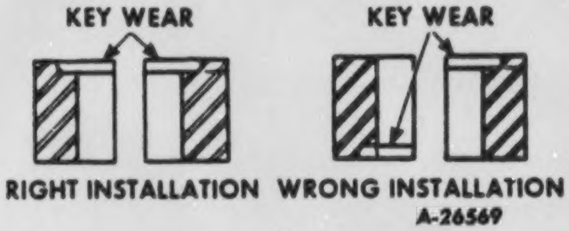

Fig. 75 - Right and Wrong Valve Key Installation.

Sodium Cooled Valves

Sodium cooled valves are very much like conventional valves in appearance, and they are serviced and adjusted for the engine in the same manner as covered in the foregoing paragraphs. CAUTION: When it becomes necessary to dispose of sodium cooled valves, they should be buried where they can be left indefinitely. Because of their sodium content, these valves must not be cut open indiscriminately.

Reassembly

After reconditioning operations have been performed, thoroughly clean valves and valve seats with cleaning solvent to remove all dirt, grindings or other foreign material. Coat valve stems with engine oil and install valves in the same seats to which they were checked. Place spring dampers, springs, oil deflectors (intake valves), and spring retainers into position. Compress valve spring with spring compressor tool and install valve keepers. Be sure spring retainers and keepers are correctly seated. After valves have been assembled to the head install the valve rotator caps to the exhaust valves to which they were checked.

ROCKER ARM ASSEMBLY, PUSH RODS AND VALVE LIFTERS (TAPPETS)

Rocker Arm Assembly

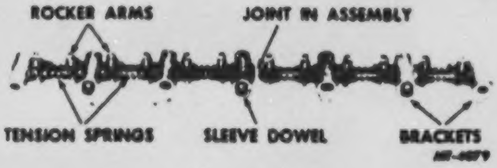

Fig. 76 - Rocker Arm Assembly.

The rocker arm assembly should be completely disassembled and thoroughly cleaned and inspected. The assembly consists of the rocker arm shafts, shaft mounting brackets, rocker arms, and tension springs for maintaining proper distance between rocker arms. When removing rocker arms, springs and mounting brackets from shafts, keep all parts in order so that if in satisfactory condition they will be returned to their original position.

1. Remove rocker arm shaft mounting bolts and flat washers from brackets and separate forward and rear shafts from center bracket. Remove brackets, springs, and rocker arms from shafts. To remove shafts from end brackets, drive roll pins from brackets.

2. Clean all parts thoroughly in cleaning solvent, making sure all oil passages are open. Formation of sludge in oil passages of rocker arms and shafts will restrict oil flow to rocker arm bushings and valves.

3. Inspect rocker arm shafts for wear from rocker arms. Check shafts on a flat surface for being bent or warped. Replace shaft if bent or worn-excessively.

4. Check rocker arm bushing for proper clearance to shaft. Refer to "Specifications". If bushings are worn beyond limits, replace rocker arms.

5. If rocker arm shaft bushings are satisfactory for reuse, inspect valve stem contact surfaces of rocker arms. Resurface if wear is indicated. Do not remove more than .010" of material when resurfacing rocker arms. Replace rocker arms having more than .010 wear.

6. Inspect rocker arm adjusting screws for wear at contact surface and for damaged threads. Replace any that are defective.

7. Replace any defective tension springs.

8. If necessary to replace expansion plugs in end mounting brackets, install plug to dimension shown in Fig. 77.

9. Assemble rocker arm shafts to end mounting brackets. Align small notch near end of shaft with roll pin hole in bracket. See Fig. 77. Install roll pin with slot away from rocker arm shaft.

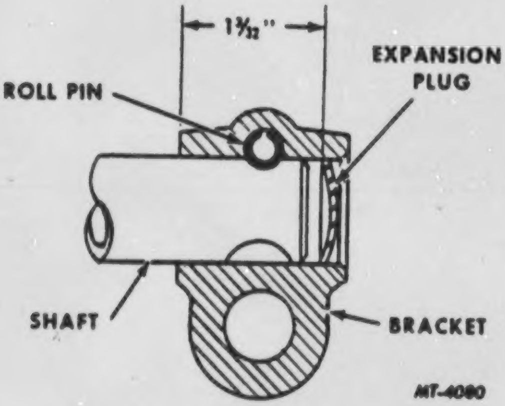

Fig. 77 - Installation of Rocker Arm Shaft to End Support Bracket.

10. Lubricate rocker arm bushings with engine oil. Assemble rocker arms, springs and brackets to rocker arm shafts. Be sure to position bracket with oil-feed passage to index with oil-feed hole in cylinder head (third from front).

11. Assemble mounting bolts and washers to shaft brackets.

Push Rods

Check all valve lifter push rods for straightness by rolling on a flat surface. See Fig. 78. Check push rods for loose or worn ends. Replace any rods which are bent, have loose ends, or are worn.

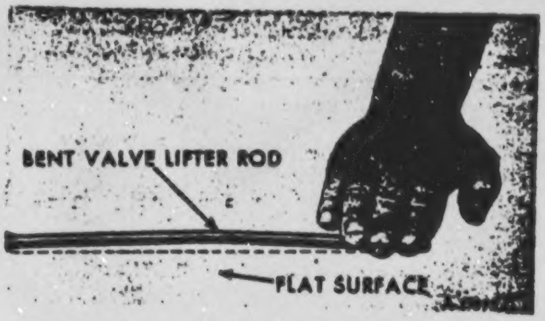

Fig. 78 - Checking Push Rod for Straightness

Valve Lifters (Tappets)

Inspect each of the 12 engine valve lifters (tappets) for excessive or irregular wear, chipping, cracking, or scoring. Check lifter running clearance in block. (See "Specifications"). Replace any that may be defective.

OIL PUMP

The oil pump is of the gear type (Fig. 79), and operates on the principle of displacement; that is the teeth on opposing gears displace oil contained between teeth on opposite gears. Since the oil is confined to the spaces between the teeth by a close fitting pump body and cover, pressure results. Because the pump is simple in design it usually requires little servicing, and all other items of the lubricating system should be checked before determining that the pump is at fault. An understanding of how the pressure lubricating system works and how the oil pump operates should be realised before going ahead with pump service. This will also help in finding many troubles which occasionally develop in the engine or even in the pump itself. Connecting rod and main bearing failures can sometime be attributed to the oil pump for other reasons than a lack of oil. For example, the scratches or flaked out areas sometimes found on engine bearings can be caused by iron or steel particles that have been worn away from an oil pump that is out of adjustment. A brief description of the lubricating system and oil pump operation follows:

Oil in the lubricating system is pumped from the oil pan by means of the oil pump into the engine's oil gallery or oil lines. A sufficient quantity is delivered to provide an adequate safety factor so that when engine wear occurs there will still be oil and pressure in reserve. To prevent the excess oil thus provided from being forced through the bearings or

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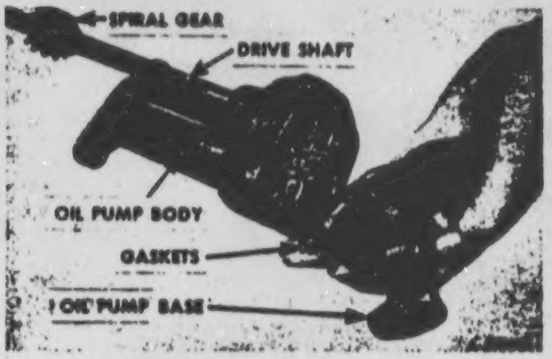

Fig. 79 - Oil Pump

restricted oil holes, a by-pass relief valve is installed in the system. This relief valve is spring-loaded so as to remain closed until a predetermined pressure is reached. At this pressure the excess oil delivered by the oil pump will be by-passed to the oil pan without going through the bearings or oil filter unit.

When bearing wear is so great that the full pump delivery is forced through the bearings and restricted oil holes with no oil being by-passed, then a point has been reached when further bearing wear will cause a reduction in the oil gauge pressure reading. Since the oil pump has a larger capacity than is normally required, considerable bearing wear can result before there will be any noticeable reduction in the gauge pressure. If however, the oil pump capacity is reduced because of excess wear in the pump assembly, and the output of the pump is close to the normal requirements of the engine, then a relatively small amount of bearing wear will result in reduced oil pressure gauge readings. The following items should be especially looked for when checking the lubricating system.

1. Improper running clearance at engine bearings.

2. Weakened oil pressure relief spring or the relief valve stuck open.

3. Cracks in the main oil gallery or leaks at other places along the oil passage ways.

A study of how the oil pump operates (Fig. 80) shows that pressure is developed by drawing oil from the oil pan into the pump body at the inlet and passing the oil around the outside of the oil pump gears to the outlet or pressure side. From here the oil is supplied under pressure to all components of the engine lubricating system. The pressure developed is dependent on the clearance existing at the various bearings, the cleanliness of the oil filter, and the condition of the oil pressure regulating valve and spring.

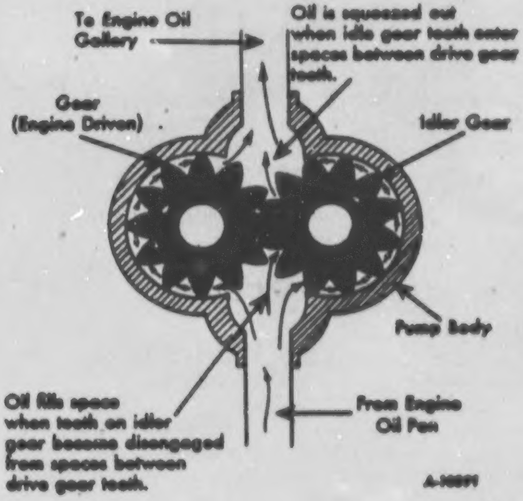
To Engine Oil Gallery
Oil is squeezed out when idle gear teeth enter spaces between drive gear teeth.
Gear (Engine Driven)
Idler Gear
Pump Body
Oil fills space when teeth on idler gear become disengaged from spaces between drive gear teeth.
From Engine Oil Pan
A-10891

Fig. 80 - Oil Flow Through Gear Type Oil Pump.

The pressure build-up on the outlet side of the pump exerts pressure against the oil gears towards the inlet side of the pump. As the pump drive shaft and its bearing in the oil pump body wear, the clearance between the outside diameter of the gears and the body diminishes gradually on the inlet side and increases on the outlet or pressure side.

After considerable operation, the specified or original body to gear clearance will decrease on the inlet side of the pump until the gears may actually rub against the housing. When this happens, some metal particles are removed from both parts. A part of this metal is immediately circulated with the oil. Some of this metal will be stopped by the filter if it is kept clean, but the damage results if any of these particles get to the main or connecting rod bearings.

Another effect of the rubbing of oil pump gears against the oil pump body is the increased wear and load on the pump itself. This results in possible breakage of the oil pump

Continued on next page

drive gears at the top of the pump shaft and on the camshaft. The load on the drive gears is further increased by metal particles lodging between the pump gear teeth and also between the lower ends of the pump gears and the pump cover. This will cause scoring of contact surfaces, additional friction, and finally overheating of the oil.

The above conditions may not be encountered every time an engine is rebuilt; however, the effects resulting from a neglected oil pump are serious enough to warrant a thorough cleaning and inspection of the pump whenever an oil pan is removed for any engine repair.

Service. The recommended inspection and repair procedures are as follows:

1. Wash all pump parts and oil intake screen assembly in cleaning solvent.

2. With pump cover removed and gears and shaft in place, exert pressure against the gears with the thumb so as to push the gears toward the outlet side of pump.

3. While holding the gears in this manner, measure the clearance between outside diameter of gear and bore of housing (Fig. 81). Clearance should be within the limits given in "Specifications".

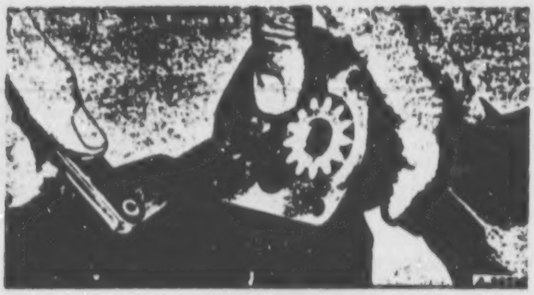

Fig. 81 - Measuring Pump Gear to Body Clearance

4. If clearance is more, obtain new parts.

5. Check pump shaft clearance in bore. To correct for wear, beyond limits given in "Specifications", replace pump assembly.

6. Check backlash between pump body gears. If this exceeds figure shown in "Specifications", replace gears.

7. Establish body gear end clearance. NOTE: Oil pump cover gaskets control clearance (end play) between pump body gears and pump cover. Add or remove gaskets to obtain desired clearance. (See "Specifications".)

8. When installing pump gears and shaft, parts should be oiled liberally with engine oil for initial pump lubrication.

9. Install pump drive gear on shaft and install dowel pin. When installing a new shaft, it will be necessary to drill a 1/8 inch diameter hole for the pin at the dimension shown in Fig. 82.

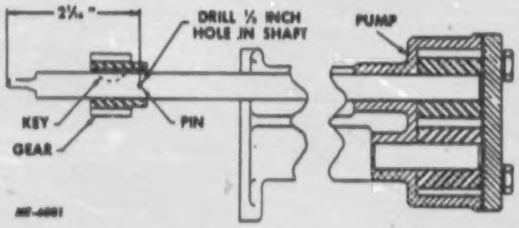

Fig. 82 - Oil Pump Drive Gear Installation.

10. Place new "O" ring seal on screen assembly. Lubricate seat with engine oil. Assemble screen to pump carefully to avoid damaging seal. Install cotter pin.

OIL PAN

The oil pan should be thoroughly cleaned in solvent. Remove all old gasket material from the oil pan flange.

Inspect pan for cracks or deformations. Weld or repair as needed. Check the mounting flange carefully to make sure it will make a tight seal when installed on crankcase.

Check oil pan drain plug and drain plug boss for fit and thread wear. If the plug is loose or the threads are damaged, repair the threads or replace the oil pan.

OIL FILTER

The full-flow oil filter utilizes a paper element which filters all oil entering the engine oil passages from the oil pump. The oil filter base contains two valves. The pressure regulator (high pressure) valve controls maximum oil pressure in the system. The filter by-pass (low pressure) valve permits oil to by-pass the filter if the filter element becomes clogged, thereby maintaining a supply of oil to the engine.

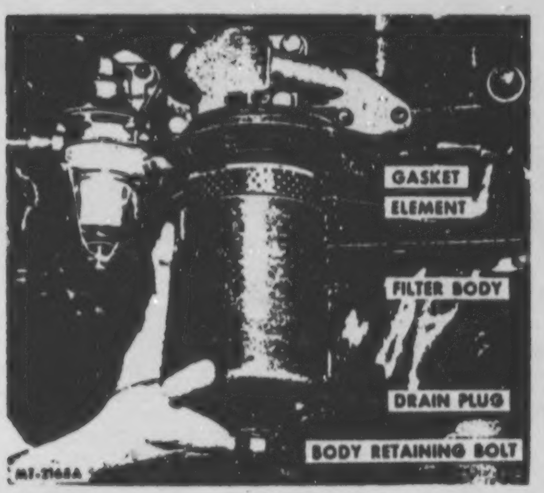

Fig. 83 - Oil Filter.

The high pressure valve controls the maximum oil pressure in the system at 50-55 psi. Oil relieved by the regulator valve is directed back into the oil pan.

The low pressure valve by-passes oil to the engine oil passages when filter element becomes contaminated and operates at 12-15 psi pressure differential. Oil pressure in the main oil gallery is determined by the pressure regulator valve less the oil pressure drop through the filter element. Approximate pressure drop with a new element is 1 to 2 psi. As filter element becomes clogged oil gallery pressure continues to drop until 12-15 psi difference in pressure is reached. At this point, low pressure (by-pass) valve permits the oil to by-pass the filter element and enter the engine oil gallery unfiltered.

The high pressure (pressure regulator) valve and the low pressure (by-pass) valve can be identified by the letters "H" and "L" adjacent to the valve bores in the filter base.

Replacing Filter Element

Frequency of oil filter element changes depends entirely upon the type of operation, road conditions, mechanical condition of engine, and quality or type of oil being used. Filter element life cannot be determined by mileage or hours of operation alone.

Should changing the oil filter element be neglected when the cartridge becomes filled with contaminants, the filter will cease to function, permitting unfiltered oil to enter engine and contaminants to accumulate within the engine. This will shorten the life of future elements and new oil, until such time as the engine is again clean.

Procedure for Servicing the Oil Filter is as Follows:

1. Remove drain plug in bottom of filter body, and drain oil from filter. Reinstall drain plug.

2. Loosen filter body retaining bolt and remove filter body and element. Check condition of filter body to base gasket; replace if necessary.

3. Wash filter body in cleaning fluid making sure all the sediment is removed from inside of filter body.

4. Position new element on filter base with seal in end of element away from base, as shown in Fig. 84.
CAUTION: Element must be seated on pilot of filter base to avoid damaging element when filter body is installed.

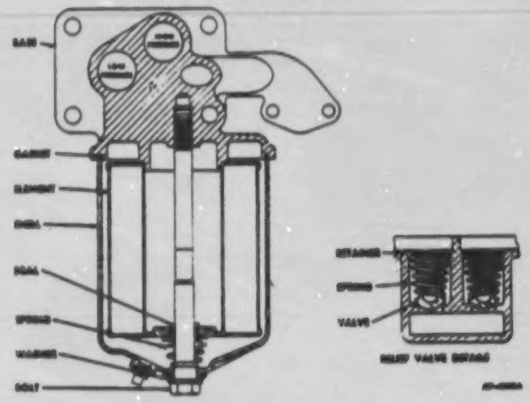

Fig. 84 - Sectional View of Oil Filter.

5. Install filter body and bolt with spring assembly to filter; make sure filter body seats on seal in filter base. Tighten filter body retaining bolt to specified torque.

6. Start engine and run for at least five minutes to warm oil and check for leaks.

7. Check engine oil level. Lubricant capacity of the full flow oil filter is approximately one quart.

Servicing Oil Filter

At the time of engine overhaul, the oil filter assembly should be thoroughly cleaned and inspected. Replace any parts showing wear or damage. Disassembly and reassembly instructions are outlined below. Work area should be clean.

1. Drain oil from filter. Remove filter shell bolt and separate shell from filter base. Remove and discard filter element.

2. Thoroughly clean filter shell and exterior of filter base.

3. Remove spring retaining ring from high pressure ("H") valve. Look for small tang on spiral type retaining ring and pry ring toward center of valve bore. After ring has started from valve bore, pry with screwdriver between valve bore and ring until ring is completely removed from bore. On filters that have snap ring type retainers, use snap ring pliers for removal.

CAUTION: Cover valve bore opening with wiping cloth prior to complete removal of valve spring retaining ring to keep valve components from scattering and to avoid possible injury.

4. Remove low pressure ("L") valve components. Use procedure given in step 3 above.

5. Clean valves, valve springs and valve bores to remove accumulation of dirt or foreign material.

6. Inspect valves for wear. Replace if wear is indicated. Test springs for proper tension. See "Specifications". Replace springs showing improper tension, wear, or damage.

7. Insert valves "H" and "L" into their respective bores. Install high pressure and low pressure springs in their respective bores with small end of springs over shoulders of valves.

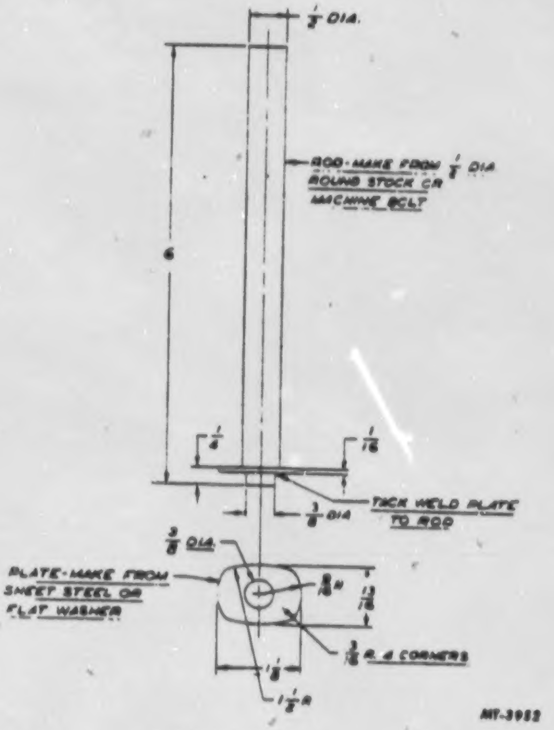

Fig. 85 - Spring Compressor Tool to Assist in Valve Spring Retaining Ring Installation.

8. To assist in installing valve spring retaining rings, a tool, as shown in Fig. 85, can be made locally.

9. Place filter base in drill press. Place plate of spring compressor tool over spring. Place retaining ring over tool. Align tool with chuck of press and depress spring into valve bore until top of spring and plate of tool recede below retaining ring groove. See Fig. 86.

10. Install retaining ring in ring groove, making sure it is correctly seated. Relieve press pressure on spring. To remove compressor tool, press on tool and tip to side and remove.

11. Install new filter element. Install new filter shell-to-base gasket. Assemble filter shell to base and install shell bolt. Tighten bolt to specified torque. See "Torque Chart" on page 7.

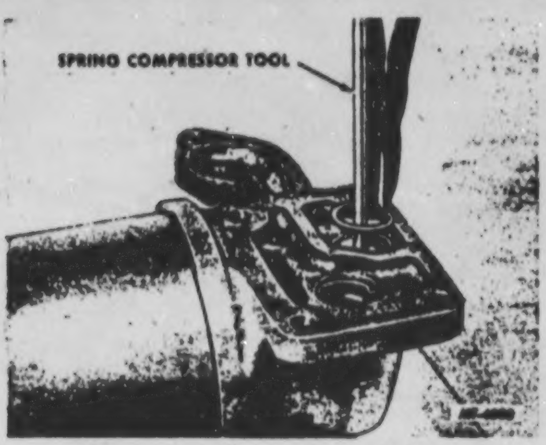

Fig. 86 - Installing Valve Spring Retaining Ring

FLYWHEEL AND RING GEAR

Clean the flywheel and ring gear with cleaning solvent, removing all traces of oil and grease. Inspect flywheel for cracks, heat check, or other defects that would make it unfit for service. Inspect the flywheel ring gear. If teeth are damaged or if ring gear is loose on flywheel, replace ring gear. Check flywheel mounting bolt holes for wear. Also check mounting face of flywheel for looseness.

To replace the flywheel ring gear, heat the gear with a torch and remove it from the flywheel with a hammer and drift. Heat the new ring gear with a torch, heating evenly all the way around. While gear is hot, install it on the flywheel and allow it to cool.

MANIFOLDS

Intake and exhaust manifolds are bolted together as a unit, and must be further disassembled for service or replacement. To separate the manifolds, remove the bolts and nuts from the center section of the assembly. The intake manifold has a threaded inlet to furnish vacuum for accessory units.

Clean the manifolds of all carbon deposits and inspect carefully for cracks and evidence of leakage. Replace any cracked or damaged parts. Place manifolds on surface plate or use straightedge to check for warpage. If slightly warped, true up on surface grinder. If warped more than 1/32 inch, replace manifold.

Manifold Heat Control Valve

The manifold heat control valve is located in the outlet of the exhaust manifold. Normally it does not require replacement unless it becomes inoperative due to excessive corrosion or damage.

Instructions for replacing the heat control valve are as follows:

1. Separate intake and exhaust manifolds.

2. Before removing the control valve note position of counterweight in relation to valve plate.

3. Remove thermostatic spring from end of shaft.

4. Using a hacksaw blade or acetyline torch, cut the shaft on both sides of the valve plate. Remove the valve and shaft pieces.

CAUTION: Avoid damaging shaft bearing bores when cutting shaft.

5. Clean the bushings of corrosion and repair any damage. Replace the bushing if necessary. When new bushings are installed, there should be a distance of 2-5/8 inches from the inside edge of one bushing to the inside edge of the other bushing. The bushing should equally be spaced within the bores. After installation, inside diameter of bushing should be .3175 - .3185. Ream if necessary.

6. Insert new shaft through the bushings and new valve plate. Lubricate the shaft and bushings with a mixture of penetrating oil and graphite. With valve in "heat-on" (closed) position, rotate shaft until counterweight is in correct location. See Fig. 87.

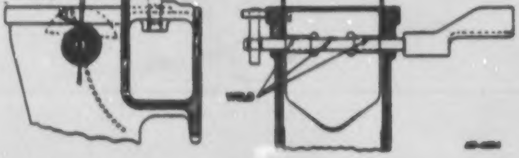

Fig. 87 - Details of Manifold Heat Control Valve

7. Tack weld the valve plate to the shaft, then move the assembly back and forth to check for binding. If there is no binding, weld the valve to the shaft in the original manner.

8. Install the thermostatic spring in the shaft slot. Wind the spring about 1/2 to 3/4 turn and hook the end of the spring over the stop pin. The spring should hold the valve in the closed or "heat-on" position (the proper position to direct flow of exhaust gases into the heat riser).

9. Lubricate the bushings while operating the valve manually to replace lubricant lost by the welding operation.

Assembling Manifolds

When assembling intake and exhaust manifolds, it is important that they be aligned properly. This can be accomplished as follows:

1. Position intake manifold to exhaust manifold using new gasket.

2. Install intake manifold-to-exhaust manifold bolts and nuts, but do not tighten.

3. Assemble manifolds to cylinder head with intake manifold pilot rings in position.

4. Install manifold mounting bolts and tighten only snug. This will align manifolds with correct relation to cylinder head.

5. Tighten intake manifold-to-exhaust manifold bolts and nuts to specified torque.

THERMOSTAT

The thermostat in the cooling system restricts water flow through the radiator during the warm-up period. When the water in the cylinder block approaches the temperature of efficient engine operation, the thermostat valve will open slightly to permit a partial flow of water through the radiator. As the water temperature increases, the valve opens further. Maximum water flow is allowed when the valve is fully open. Since a low operating temperature will result in loss of power and economy, only the specified temperature range thermostat should be used. The thermostat should not be removed in an attempt to lower the operating temperature.

If the thermostat is believed to function improperly, it should be removed and checked. Place the thermostat in a pan of water. Heat the water and, using an accurate thermometer, check the temperature of the water when the thermostat starts to open. The thermostat should start to open at the specified temperature given in "Specifications". If thermostat is defective, it must be replaced.

When installing the thermostat, position the valve end of the thermostat into the water outlet housing and make sure thermostat is seated. Use a new gasket when assembling water outlet housing to cylinder head.

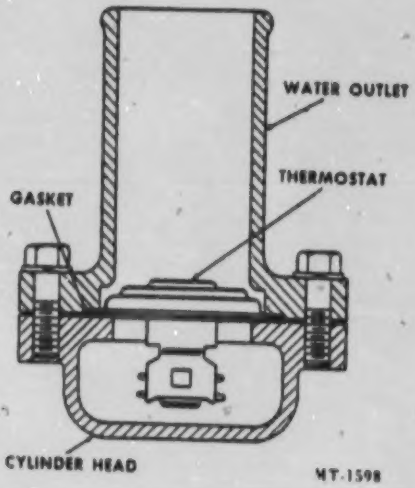

Fig. 88 - Thermostat Installation.

WATER PUMP

To disassemble the water pump, the following steps are necessary:

1. Remove three screws from back cover plate and take off plate and gasket from pump body (Fig. 89).

2. Remove snap ring from front of water pump shaft bearing.

3. Support water pump on an arbor press and push shaft and bearing out of body and impeller (Fig. 90).

4. Place shaft assembly in press and press fan hub from shaft (Fig. 91). CAUTION: Do not attempt to remove bearing or slinger from shaft as these are factory installed, in the proper location.

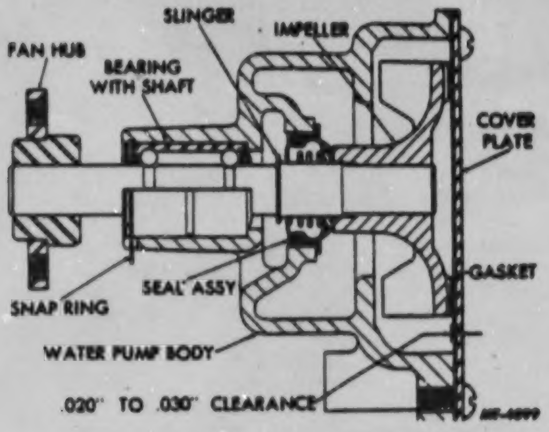
SLINGER
IMPELLER
FAN HUB
BEARING WITH SHAFT
COVER PLATE
GASKET
SEAL ASSY
SNAP RING
WATER PUMP BODY
.020" TO .030" CLEARANCE

Fig. 89 - Sectional View of Water Pump

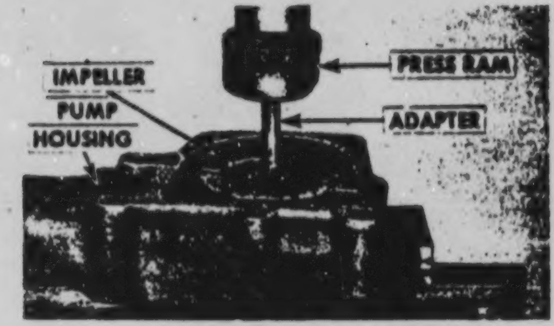
IMPELLER
PUMP HOUSING
PRESS RAM
ADAPTER

Fig. 90 - Pump Shaft and Bearing Removal

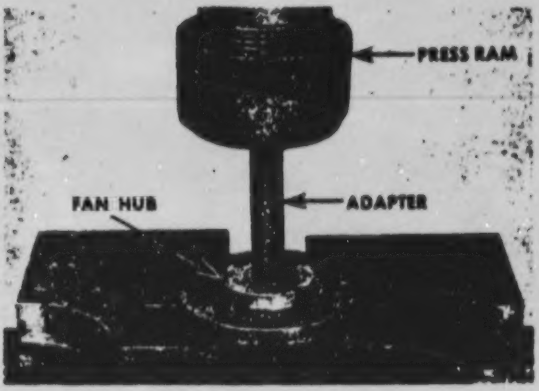
PRESS RAM
FAN HUB
ADAPTER

Fig. 91 - Fan Hub Removal

5. Remove seal from body through back side of water pump. Use a drift and drive the seal from pump body. To determine worn or damaged parts to be replaced, check as follows:

a. Clean all parts (except rubber parts) in solvent.

b. Inspect pump shaft and bearing assembly for wear and replace if necessary.

c. Examine impeller seal seat surface. If seat face is scored, it must be resurfaced or impeller must be replaced to prevent leakage.

d. Always use a new seal when rebuilding the pump since the old seal may have been damaged on removal.

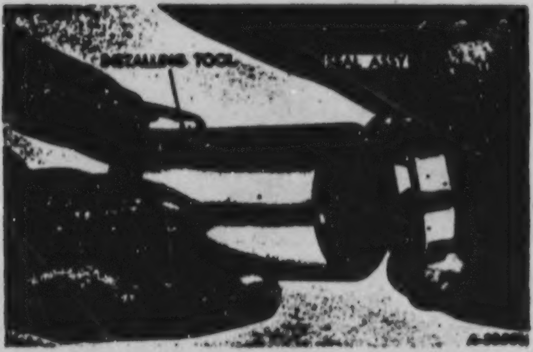
INSTALLING TOOL
SEAL ASSY

Fig. 92 - Water Pump Seal Installer Tool - SE-1721

To reassemble pump, proceed as follows:

1. Place the new water pump seal assembly on installing tool, SE-1721, (Fig. 92). Place pump body in press and, after aligning seal and installing tool, press seal into body (Fig. 93).

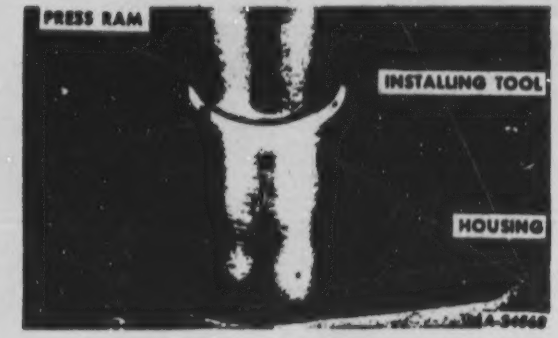
PRESS RAM
INSTALLING TOOL
HOUSING

Fig. 93 - Installing Water Pump Seal

2. Press fan hub on end of shaft so that the smaller diameter of hub faces to the front (Fig. 94).

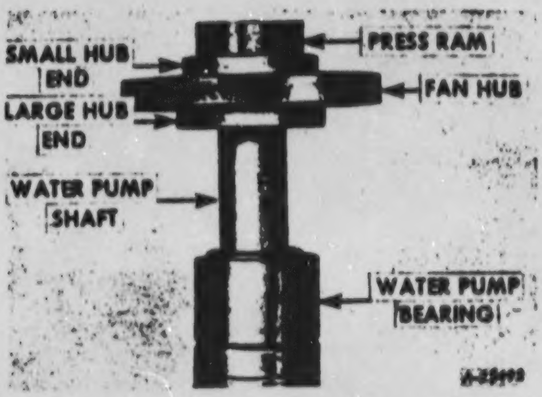

Fig. 94 - Installing Fan Hub on Shaft

3. Install shaft in housing from front end by pressing shaft, bearing, slinger, and fan hub in as one unit. Install snap ring in place behind fan hub.

4. Mount assembly in press and install impeller on rear end of shaft. Place a straightedge across the back of the water pump housing and check the clearance between straightedge and impeller (Fig. 95).

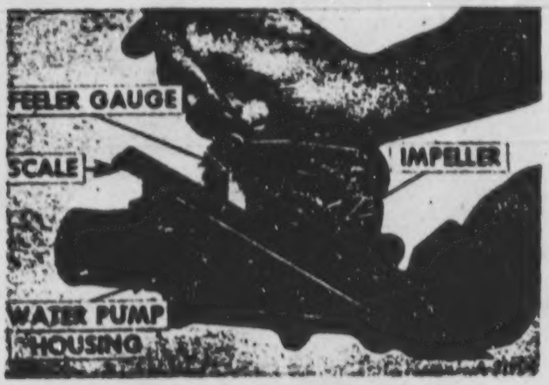

Fig. 95 - Measuring Water Pump Cover-To-Impeller Clearance

5. Place gasket and cover plate on pump and secure with three round head screws.

REASSEMBLY AND INSTALLATION

REASSEMBLY OF ENGINE

When assembling the engine, refer to the "Torque Chart" and use a torque wrench to tighten all bolts and nuts to specified torque. Correct tightening of bolts is very important to avoid distortion or damage to engine parts by overtightening and leakage or looseness from undertightening.

1. After all parts have been thoroughly cleaned and reconditioned, and the necessary replacement parts have been procured, mount cylinder block in engine stand in position for assembly. Rotate engine stand so bottom of block faces upward.

2. Make sure all core plugs and drain plugs are in place in cylinder block.

3. Coat the camshaft lobes, journals and bushings with heavy duty hypoid axle lubricant. This is to provide initial lubrication.

NOTE: Throughout the assembly procedure instructions are given to pre-lubricate engine bearing and sliding contact surfaces with engine oil. When assembling engines which will not be used for a period of time, lubricate the bearing surfaces with a grease such as "Lubriplate 630AA". This lubricant will not drain from the bearing surfaces during the storage period.

4. Insert the camshaft into position in the camshaft bearings. To help prevent nicking and damaging camshaft bearings, use installer tool SE-1880, as shown in Fig. 96.

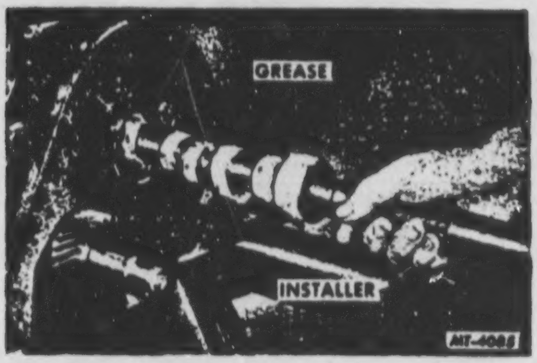

Fig. 96 Installing Camshaft using SE-1800 Installer Tool

5. Install camshaft thrust flange and mounting bolts. Tighten bolts to specified torque.

6. Use dial indicator to check camshaft end play. If end play exceeds limits listed in "Specifications", replace the camshaft thrust flange.

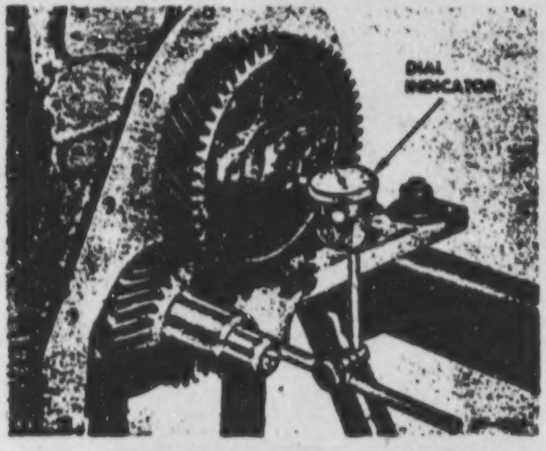

Fig. 97 - Checking Camshaft End Play

7. Position camshaft gear key in keyway of shaft. Lubricate I.D. of gear with engine oil and position gear on shaft to align with key. Use installer SE-1900 and adapter SE-1900-2 to press gear into position. Install lock plate and camshaft gear nut. Tighten nut to specified torque and bend lock down over one face of nut.

NOTE: Camshaft gear may be pressed onto shaft before camshaft is installed. Be sure to position thrust plate on shaft before installing gear.

8. Position crankshaft gear key in keyway of crankshaft. Lubricate I.D. of gear with engine oil and position gear on shaft to align with key. Press gear into position. Installer SE-1900 and adapter SE-1900-4 can be used to install gear when crankshaft is mounted in crankcase.

9. Install oil seals in crankcase and rear main bearing cap. Use SE-1720 Oil Seal Compressor Tool to press or roll seals into place. After seal is seated in crankcase or cap, trim off ends of seal that project above cap surface level. See Fig. 100. Lubricate face of seals with grease such as "Lubriplate".

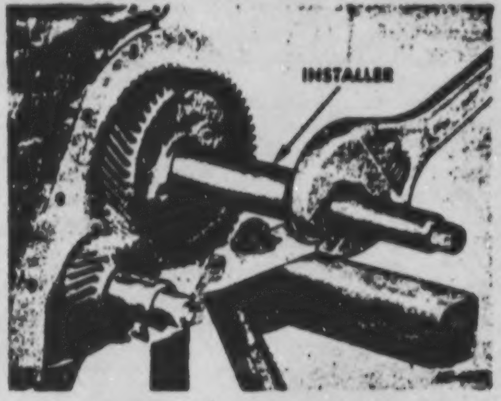

Fig. 98 - Installing Camshaft Gear Using SE-1900 Installer Tool

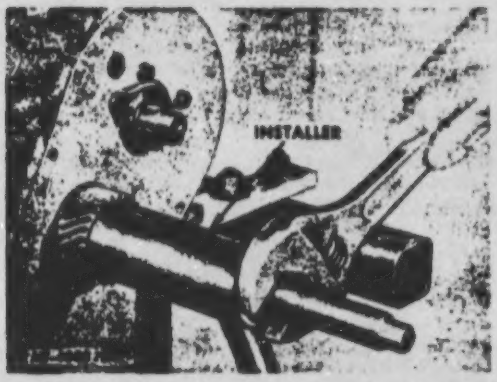

Fig. 99 - Installing Crankshaft Gear Using SE-1900 Installer Tool

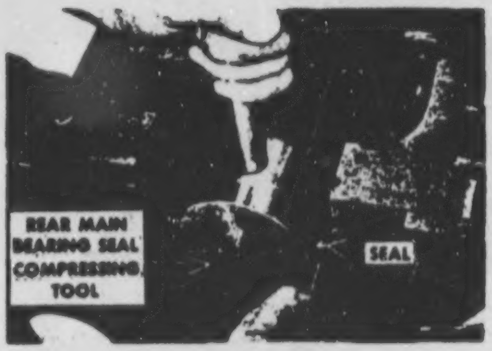

Fig. 100 - Installing Upper Oil Seal in Crankcase using SE-1720 Oil Seal Compressor Tool

10. Wipe main bearing bores of crankcase to remove any dust or dirt. Place the upper halves of the bearing inserts in the bearing bores. Make sure oil holes are aligned, the inserts are seated in the bores and that the tangs fit into the recesses. Similarly, wipe bearing caps and install lower halves of bearing inserts.

11. Lubricate bearing inserts with engine oil. Lift the crankshaft into position in the bearings, aligning the timing marks on crankshaft and camshaft gears.

12. Place main bearing caps (with bearing inserts) over the crankshaft main bearing journals. Be sure numbers are on camshaft side of engine. Lubricate threads of bearing cap bolts with engine oil and install bolts and flat washers. Tighten bolts evenly until snug (not to specified torque). Using a soft hammer, tap each bearing cap until both faces of the cap are flush with the machined faces of the crankcase. Alignment of the faces will assure proper cap location. Check alignment at both sides (left and right) of the bearing cap.

13. Tighten main bearing cap bolts to specified torque.

14. Check crankshaft end play with a dial indicator, as shown in Fig. 101. End play should be within limits listed in "Specifications".

Fig. 101 - Checking Crankshaft End Play

15. Rotate crankshaft and camshaft to determine that gears do not bind or interfere. Check timing gear backlash with a dial indicator, as shown in Fig. 102. Backlash should be within limits listed in "Specifications".

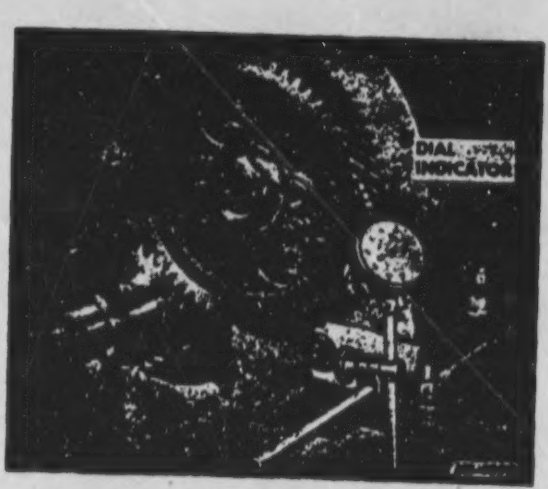

Fig. 102 - Checking Timing Gear Backlash

16. Place front cover oil seal in engine oil until seal is completely saturated. Work oil seal into channel of front cover. Be careful not to damage seal. See Fig. 103.

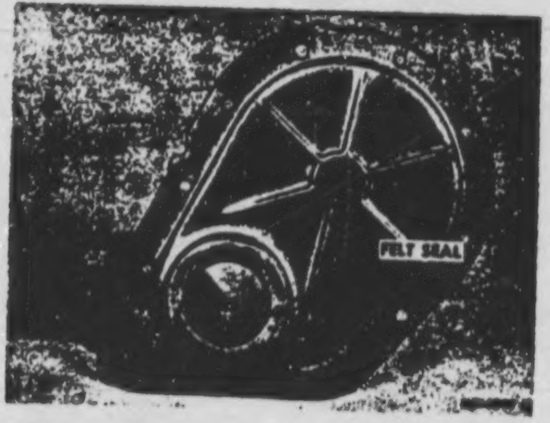

Fig. 103 - Installing Front Cover Oil Seal

17. Place crankshaft oil slinger over end of crankshaft. Install crankshaft pulley key in keyway of shaft. Assemble engine front timing gear cover and gasket to crankcase.

18. Using SE-1717 Aligning Tool, position front cover and install mounting bolts and nuts. Remove aligning tool.

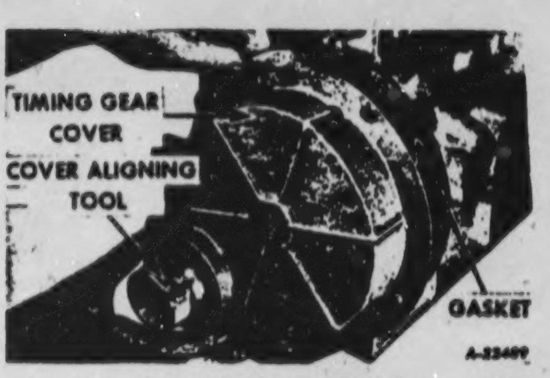

Fig. 104 - Aligning Timing Gear Cover with SE-1717 Aligning Tool

19. Position crankshaft pulley on crankshaft, aligning keyway with key. Using SE-1900 Installer Tool and SE-1900-4 Adapter, press pulley into position. Install crankshaft pulley nut and washer and tighten to specified torque.

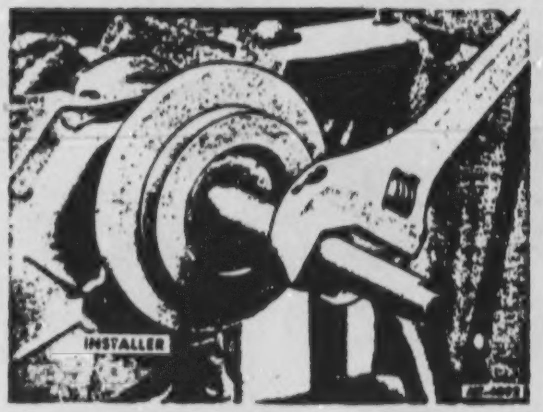

Fig. 105 - Installing Crankshaft Pulley

20. Install rear main bearing cap side oil seals. Use an installer tool made from 1/8" welding rod. To make the tool, puddle a ball on the end of the rod and file to approximately 5/32" diameter. See Fig. 106.

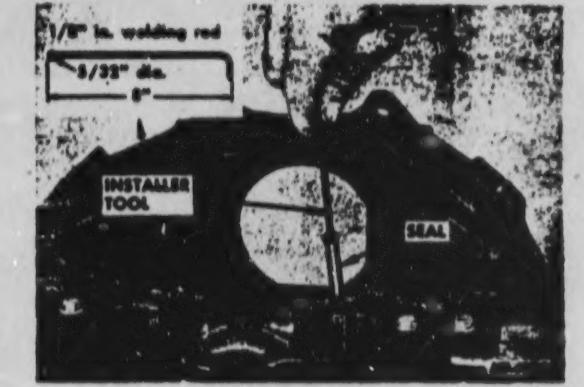

Fig. 106 - Installing Rear Main Bearing Cap Side Oil Seals

21. Place flywheel housing or adapter in position over crankcase dowels and tap into position with a soft hammer. Install mounting bolts and lockwashers and tighten to specified torque. NOTE: If necessary to replace cylinder block, one-piece flywheel housing or adapter, the flywheel housing alignment will have to be re-established and dowel pins reamed for oversize dowels. If possible, align flywheel housing with the engine in vertical position (flywheel housing up). Procedure for establishing correct alignment is as follows:

a. Remove present dowels from crankcase. Be careful not to damage crankcase.

b. Assemble flywheel housing or adapter to crankcase. Tighten mounting bolts only "snug" to permit movement of the housing. On two-piece housing, assemble flywheel or converter housing to adapter and tighten mounting bolts securely.

c. Install housing aligning fixture (SE-1834) with dial indicator onto crankshaft flange. See Fig. 107.

d. Rotate engine and check housing run-out. The permissible run-out (see "Specifications") can be obtained by using a soft mallet to shift the housing on the crankcase. After correct alignment is obtained (run-out within limits), tighten the housing (or adapter)-to-crankcase bolts to specified torque. Remove aligning fixture.

e. Working from engine side, ream dowel holes with SE-1847-3 reamer (.030 inch oversize).

f. Drive new dowel pins into crankcase and housing (or adapter). Dowel pins must be driven in from engine side to avoid possible damage to crankcase.

g. On two-piece housing, remove flywheel or converter housing from adapter to permit installation of flywheel and clutch.

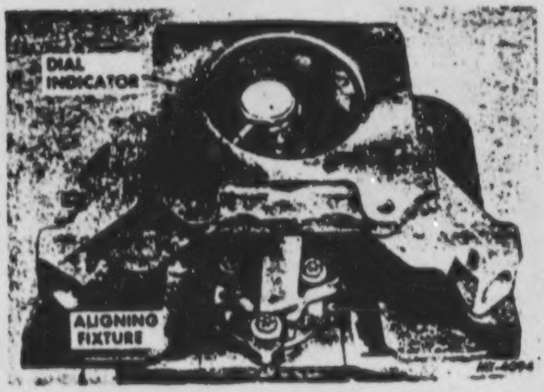

Fig. 107 - Checking Flywheel Housing Alignment

22. Assembly flywheel (with ring gear) to crankshaft flange. Apply sealing compound to threads of bolts and install bolts. Be sure flywheel is seated squarely on flange. Tighten mounting bolts alternately and evenly to specified torque.

23. Install clutch pilot bearing into the flywheel. Rear of bearing should be flush with rear of flywheel at bearing bore.

24. Assemble the clutch driven disc to the flywheel so that the long part of the hub is toward the rear. Use an aligning arbor or transmission main drive gear shaft to align the driven disc. Install clutch assembly on flywheel with spot of white paint on clutch as near as possible to "L" stamped on flywheel. Start all mounting bolts. Tighten mounting bolts alternately and evenly to specified torque. Remove retaining clips or bolts used to hold clutch compressed.

25. Wipe cylinder bores to remove any dust or foreign material.

26. Install pistons, rings and connecting rods as follows:

a. Rotate engine until No. 1 crankpin is at the bottom of its stroke.

b. Place upper half of connecting rod bearing insert in No. 1 connecting rod. Make sure insert is correctly seated. Lubricate bearing surface with clean engine oil.

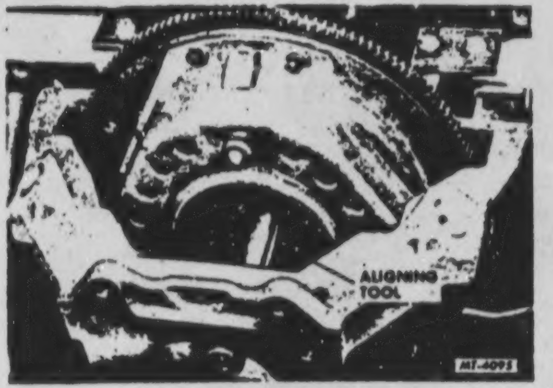

Fig. 108 - Installing Clutch

c. Dip piston assembly in clean oil to lubricate rings and install ring compressor. Install piston assembly in cylinder with arrow stamped on piston pointing toward front of engine (number on connecting rod toward camshaft). Do not strike top of piston during installation. Piston assembly should be pushed from ring compressor into cylinder bore.

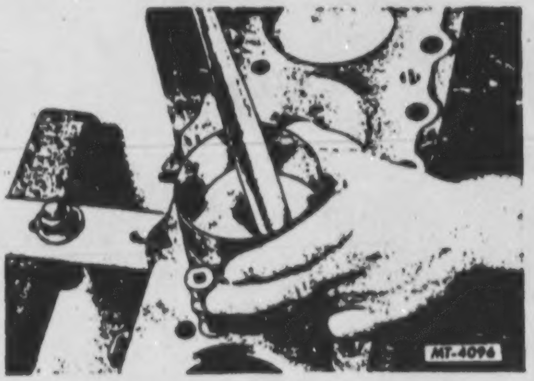

Fig. 109 - Installing Piston and Connecting Rod

d. Place lower half of bearing insert in No. 1 connecting rod cap and lubricate with oil. Assemble cap to connecting rod with number on cap and on numbered side of rod. Lubricate threads of rod cap bolts with oil and install bolts. Tighten bolts evenly to specified torque.

e. Repeat above steps to install remaining piston and connecting rod assemblies.

f. Recheck connecting rod side clearance as instructed under "Crankshaft and Bearings".

Install oil pump. Set engine on firing position for No. 1 cylinder. Position oil pump mounting gasket on cylinder block. Insert oil pump into block and mesh gears so that tang of pump shaft is at 30° angle with centerline of engine as shown in Fig. 110, when pump is installed. This places oil pump drive shaft in correct position for distributor installation. Install pump mounting bolts and lockwashers and tighten to specified torque.

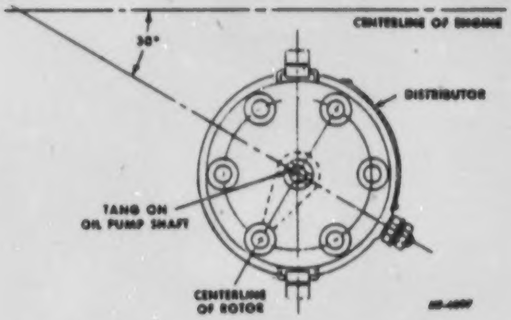

Fig. 110 - Oil Pump Installation Diagram

27. Coat valve lifters (tappets) with oil and install lifters in bores of crankcase.

28. Install valve lifter cover and gasket.

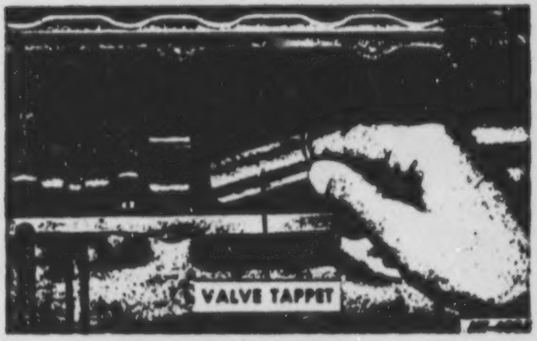

Fig. 111 - Installing Valve Lifters

29. Place cylinder head gasket on crankcase and align bolt holes. Install cylinder head on crankcase, being careful not to damage or shift gasket. A pair of aligning studs to hold the gasket in position, and guide the cylinder head can be made locally from long cylinder head bolts. Loosely install all short head bolts and flat washers.

30. Insert valve lifter (push) rods through cylinder head, making sure they enter the valve lifters.

31. Install rocker arm assembly into position on cylinder head, making sure that dowel sleeves are in place in number 2, 4 and 6 brackets.

32. Install long cylinder head bolts through rocker shaft brackets. Tighten cylinder head bolts evenly following sequence shown in Fig. 112. Do not tighten bolts fully the first time, but go over them several times. Tighten bolts evenly in correct order, working in approximately 20 foot-pound steps until all bolts have been tightened to specified torque.

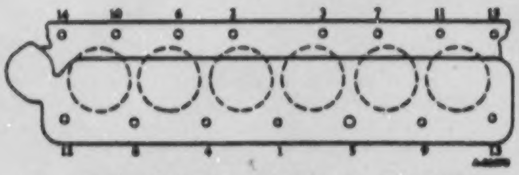

Fig. 112 - Cylinder Head Bolt Tightening Sequence

33. Adjust rocker arm-to-valve stem clearance as instructed below. To obtain correct clearance, make adjustment at each cylinder with its piston on top dead center of the compression stroke.

a. Turn engine crankshaft until No. 1 piston is on top dead center of compression stroke (both valves closed) and timing mark on flywheel is in line with pointer on flywheel housing, (Fig. 113).

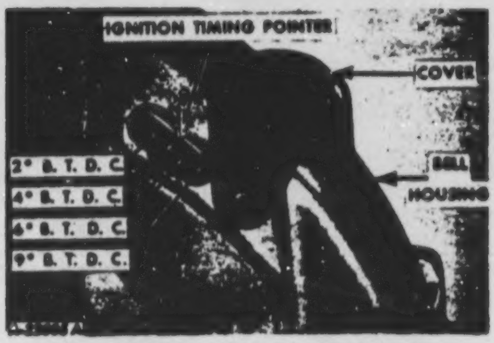

Fig. 113 - Ignition Timing Marks

b. Adjust clearance on both valves of No. 1 cylinder to correct specification. Measure clearance with a feeler gauge between valve stem and rocker arm. Loosen lock nut and turn adjusting screw until correct clearance is obtained. Tighten adjusting nut and recheck clearance.

c. Turn crankshaft one-third revolution and adjust clearance of valves of No. 5 cylinder.

d. Adjust the valves of the remaining cylinders by continuing to rotate the engine one-third revolution at a time and following the firing order sequence.

e. Temporarily install rocker arm cover to keep dirt from engine while finishing assembling and installation operations.

NOTE: Valve-to-rocker arm clearance should be rechecked with engine at normal operating temperature.

34. Install intake and exhaust manifolds. The manifolds must first be bolted together. Insert pilot rings and position the gasket on side of cylinder head. Start hex head bolts and washers into the mounting holes for outside ends of intake manifold. Slide the manifold straight up between cylinder head and washers until the manifold is lined up with the pilot rings and gasket. Tilt bottom of manifold out at the top to bind against the two bolts. This will hold the manifold in position until the front and rear bolts can be tightened down. Install the remaining bolts and tighten down to their specified torque.

35. Place water pump gasket over opening in front of crankcase and install water pump to crankcase. Secure with four hex head bolts and lock washers and tighten to proper torque.

36. Install thermostat, thermostat housing and gasket on cylinder head.

37. Install generator mounting bracket (with generator) and fan belt adjusting strap.

38. Install starting motor.

39. Install carburetor on intake manifold.

40. Install distributor, as follows:

a. Turn crankshaft so as to position No. 1 piston at T.D.C. on compression stroke. This will cause timing dot on flywheel to appear at pointer on flywheel housing.

b. Turn the shaft of the distributor assembly so that the rotor is positioned in the distributor to contact with the No. 1 terminal inside the distributor cap. (It may be necessary to mark the distributor to positively locate rotor for No. 1 position.)

c. With rotor positioned as above, insert distributor assembly into mounting hole on left side of crankcase. Allow groove of distributor coupling to engage with tang on end of oil pump drive shaft so that the distributor will bottom in its mounting. Make certain that screw hole for hold-down bolt is in center of slot in distributor vacuum control unit.

d. Recheck rotor to make sure it is in position for contacting No. 1 terminal.

e. The above procedure applies to initial timing of the engine only. Final timing should be accomplished after the engine has been installed and operated in the vehicle.

41. Install distributor cap and spark plug cables.

42. Install ignition coil to left side of cylinder head and connect high tension cable and primary ignition wire between coil and distributor.

43. Install fuel and vacuum lines on engine and connect vacuum line to carburetor and distributor vacuum control unit. Connect fuel line to carburetor.

44. Install oil pressure gauge and temperature gauge sender units.

45. Attach chain sling and crane and lift engine from rebuild stand.

46. With engine supported by hoist equipment, assemble the following:

a. Install the oil pan and gasket. Be sure oil drain plug is tight.

b. Install oil filter and gasket.

c. Install fuel pump and connect fuel line to pump.

d. Install engine front mounting bracket or struts.

ENGINE INSTALLATION

In general, installation of the engine is performed in the reverse order of removal.

1. Install lifting sling on engine and connect hoisting equipment.
2. Install engine front mounting bracket or struts on engine, if not installed previously.
3. Raise engine sufficiently to start into position in chassis. Tilt front of engine upward and lower engine into position.
4. Be sure clutch release bearing is in position. Align clutch driven disc with transmission main drive gear shaft. Push engine back into position. Connect transmission to engine, flywheel housing to adapter plate or transmission to flywheel housing. Install mounting bolts and tighten snug. Assemble engine rear mountings. Do not tighten at this time. On vehicles with automatic transmission, align adapter housing with converter housing. Push engine back into position. Install housing-to-adapter plate mounting bolts and tighten snug. Install converter-to-converter drive plate bolts and tighten to specified torque.
5. Connect engine front mounting to vehicle frame. Do not tighten at this time.
6. Be sure engine is correctly seated in mountings. Tighten front mountings, flywheel housing-to-adapter plate or transmission-to-flywheel housing bolts, and rear engine mounts to specified torque.
7. Disconnect hoisting equipment and remove lifting sling.
8. Connect exhaust pipe, fuel lines, control wires, and electrical wiring and linkage which were disconnected for engine removal.

NOTE: Be sure all controls and linkages are adjusted to operate correctly.

9. Install radiator shroud and other parts which were removed. Install radiator and heater hoses. Replace hoses if necessary.
10. Be sure all drain cocks are closed. Fill cooling system with clean water or antifreeze. Check all hoses and connections for leaks.
11. Fill crankcase with proper grade of engine oil.
12. Start engine and allow it to warm up to operating temperature. Observe oil pressure and be sure engine doesn't overheat. Check for coolant or oil leaks.
13. Connect timing light to engine and check timing. If necessary, loosen distributor retainer bolt and adjust timing. Refer to "Specifications" for timing setting. Timing marks are illustrated in Fig. 113.
14. After engine is warmed up, retighten cylinder head bolts to specified torque. Readjust valve-to-rocker arm clearance. Make final adjustments.
15. Install hood.

NOTE: Warn operator that a newly overhauled or a replacement engine requires "breaking-in" similar to a new vehicle. Advise him to follow recommended "break-in" precaution for the first 1,000 miles of operation.

ENGINE MOUNTINGS

Front Mountings

Engine mountings vary between vehicle models. Various types of front mountings are shown in Figs. 114, 115, 116, 117, 118 and 119.

When assembling front mountings of the type illustrated in Fig. 114, 115 and 116, assemble components as shown and tighten elastic stop nuts until there is no perceptible looseness, then tighten 1 to 1-1/2 additional turns.

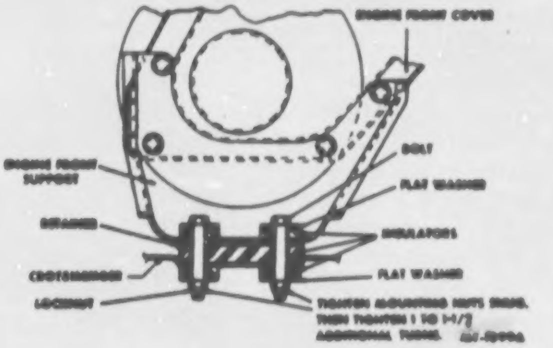

Fig. 114. Engine Front Mounting With 5-Piece Insulator(Light Duty Trucks).

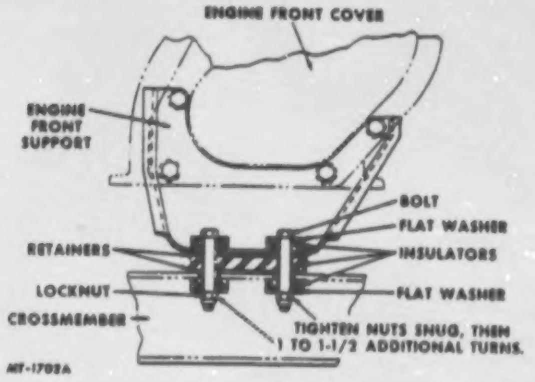
ENGINE FRONT COVER
ENGINE FRONT SUPPORT
BOLT
FLAT WASHER
RETAINERS
INSULATORS
LOCKNUT
FLAT WASHER
CROSSMEMBER
TIGHTEN NUTS SNUG, THEN 1 TO 1-1/2 ADDITIONAL TURNS.
MT-1702A

Fig. 115 Engine Front Mounting With 5-Piece Insulator (Medium-Duty Models).

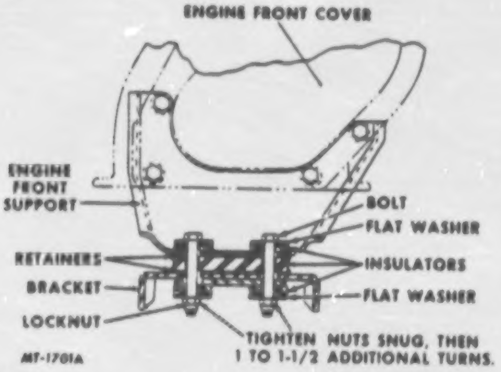
ENGINE FRONT COVER
ENGINE FRONT SUPPORT
BOLT
FLAT WASHER
RETAINERS
INSULATORS
BRACKET
FLAT WASHER
LOCKNUT
TIGHTEN NUTS SNUG, THEN 1 TO 1-1/2 ADDITIONAL TURNS.
MT-1701A

Fig. 116 Engine Front Mounting With 5-Piece Insulator (Cab Forward Models).

The engine front mounting shown in Fig. 117 utilizes a two-piece insulator with sleeves. When assembling, position components as shown and tighten elastic stop nuts to 39 ft. lbs. torque.

Figures 118 and 119 illustrate strut type engine front mountings. Assemble as shown and tighten all 1/2 inch bolts to 35-40 ft. lbs. torque.

Rear Mountings

Two types of engine rear mountings are shown in Fig. 120 and Fig. 121.

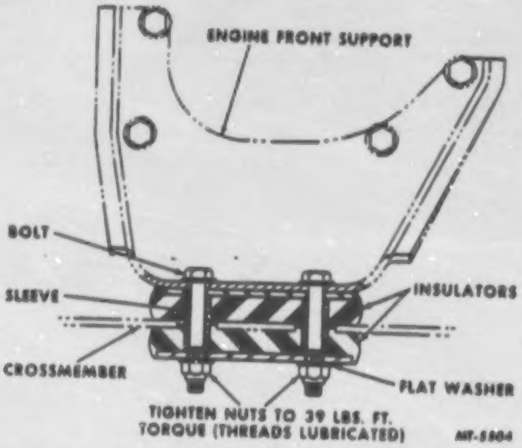
ENGINE FRONT SUPPORT
BOLT
SLEEVE
INSULATORS
CROSSMEMBER
FLAT WASHER
TIGHTEN NUTS TO 39 LBS. FT. TORQUE (THREADS LUBRICATED)
MT-5804

Fig. 117 Engine Front Mounting With 2-Piece Insulator.

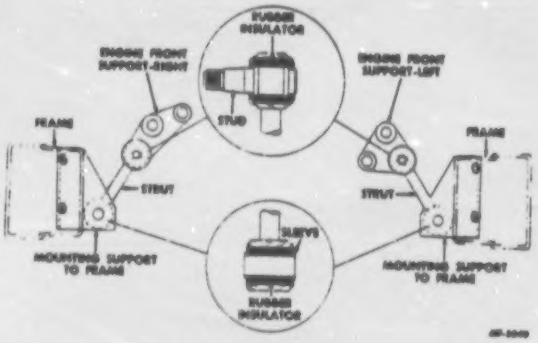
RUBBER INSULATOR
ENGINE FRONT SUPPORT-RIGHT
ENGINE FRONT SUPPORT-LEFT
STUD
FRAME
FRAME
STRUT
STRUT
SLEEVE
MOUNTING SUPPORT TO FRAME
MOUNTING SUPPORT TO FRAME
RUBBER INSULATOR

Fig. 118 Strut Type Engine Front Mounting For Chassis With Box Frame.

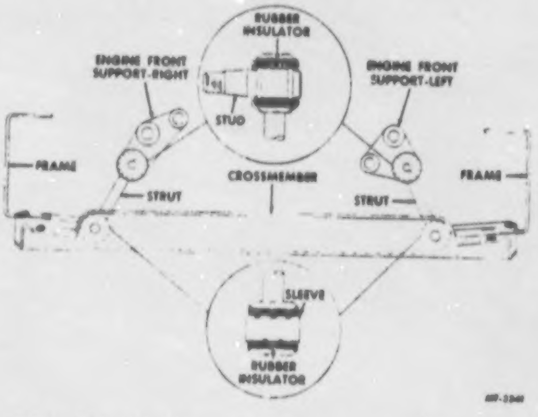
RUBBER INSULATOR
ENGINE FRONT SUPPORT-RIGHT
ENGINE FRONT SUPPORT-LEFT
STUD
FRAME
CROSSMEMBER
FRAME
STRUT
STRUT
SLEEVE
RUBBER INSULATOR

Fig. 119 Strut Type Engine Front Mounting For Chassis With Channel Frame.

When assembling rear mountings shown in Fig. 120, place upper insulator and retainer between crossmember and flywheel housing. Make sure holes in insulators and retainer align with holes in flywheel housing and crossmember. Position sleeve through crossmember and into upper insulator. Install lower insulator under crossmember and attach to flywheel housing with bolt, flat washer and lockwasher. Tighten bolt to 65 ft. lbs. torque. The rear mounting shown in Fig. 121 utilizes a one-piece mounting insulator. When assembling this type, the insulator must be properly seated in the retainer. Install retainer with two bolts, nuts and lockwashers. Install insulator bolt from the bottom of the crossmember and tighten to torque specified.

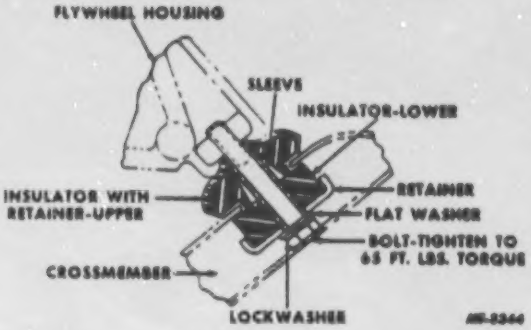
FLYWHEEL HOUSING
SLEEVE
INSULATOR-LOWER
INSULATOR WITH RETAINER-UPPER
RETAINER
FLAT WASHER
BOLT-TIGHTEN TO 65 FT. LBS. TORQUE
CROSSMEMBER
LOCKWASHER
AR-8344

Fig. 120 Engine Rear Mounting With 2-Piece Insulator.

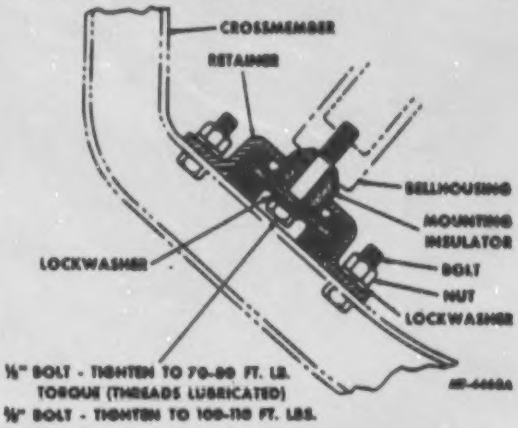
CROSSMEMBER
RETAINER
BELLHOUSING
MOUNTING INSULATOR
BOLT
NUT
LOCKWASHER
LOCKWASHER
½" BOLT - TIGHTEN TO 70-80 FT. LB. TORQUE (THREADS LUBRICATED)
⅝" BOLT - TIGHTEN TO 100-110 FT. LBS.
AR-4468A

Fig. 121 Engine Rear Mounting With One-Piece Insulator.

TROUBLE SHOOTING

PROBABLE CAUSE	REMEDY
ENGINE WILL NOT TURN OVER	
1. Cranking motor inoperative.	
(a) Battery weak or faulty.	Charge or replace battery.
(b) Cables and terminals faulty.	Inspect battery cables wiring and wiring connections. Replace cables if necessary.
(c) Starting switch defective.	Replace starter switch.
(d) Cranking motor defective.	Check motor and make necessary corrections.
2. Engine oil too heavy for operation in low temperatures.	Use grade of oil specified in Operator's Manual.
3. Internal seizure.	Determine cause for seizure and correct.
ENGINE TURNS OVER BUT WILL NOT START	
1. Cranking speed too low.	
(a) Battery weak or faulty.	Charge or replace battery.
(b) Cables and terminals faulty.	Inspect battery cables.
(c) Cranking motor defective.	Check motor and make necessary corrections.
2. Fuel system faulty.	
(a) No fuel in tank.	Fill tank with fuel

Continued on next page

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
ENGINE TURNS OVER BUT WILL NOT START - Continued	
2. Fuel system faulty - Continued	
(b) Carburetor flooded.	Open choke valve. Wait a few minutes before again attempting to start engine.
(c) Fuel pump bowl screen clogged.	Clean bowl and screen.
(d) Water in gasoline.	Drain tank, fuel pump bowl, and carburetor. Refill with clean fuel.
(e) Fuel lines clogged.	Clean fuel lines.
(f) Vent holes in fuel tank cap plugged.	Check, replace cap if necessary.
(g) Fuel pump defective.	Test fuel pump. Replace if necessary.
3. Air intake restricted or exhaust systems restricted.	Service air cleaner. Check for restrictions.
4. Ignition system faulty.	
(a) Wet or fouled spark plugs.	Remove and dry plugs. Remove carbon. Reset plug gap.
(b) Cracked or broken spark plug insulator.	Replace damaged plugs.
(c) Spark plug or ignition wiring loose or defective.	Check for loose or corroded terminals. Check for cracked or broken wiring.
(d) Point gap incorrect.	Check and readjust points.
(e) Moisture in distributor.	Remove cap and dry rotor, cap and distributor with compressed air.
(f) Broken distributor rotor.	Replace rotor.
(g) Condenser shorted or open.	Replace condenser.
(h) Broken distributor cap.	Replace cap.
(i) Dirty or pitted distributor cap terminals.	Clean terminals. Replace cap if necessary.
(j) Short or open circuit in distributor.	Locate short or open circuit or correct as needed.
(k) Ignition coil defective.	Test coil. Replace if necessary.
(l) Ignition switch defective.	Connect jumper wire from "Bat" to "Ign" terminal of switch. Try to start engine. If engine starts, switch is defective and should be replaced.

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
MISSING AND BACKFIRING BUT FAILS TO START	
1. Water in gasoline.	Drain tank, fuel pump bowl and carburetor. Fill with clean gasoline.
2. Air leaks around intake manifold.	Check manifold gasket. Tighten manifold bolts to specified torque.
3. Improper firing order.	Check ignition cables for correct installation at spark plugs and distributor cap in accordance to engine firing order.
4. Distributor not correctly timed to engine.	Check and adjust timing.
5. Moisture in distributor.	Remove cap and dry rotor, cap and distributor with compressed air.
6. Distributor cap shorting out.	Check for loose or corroded terminals, dirt or cracks.
MISFIRING OR CUTTING OUT AT HIGH SPEED	
1. Ignition system faulty.	
(a) Spark plugs fouled or worn.	Clean and test spark plugs. Replace if necessary.
(b) Point gap incorrect.	Readjust points.
(c) Weak point spring tension.	Adjust spring tension or replace points.
(d) Primary lead loose or broken.	Check lead wire and terminals.
(e) Distributor advance not operating.	Repair as needed. Replace worn or damaged parts.
(f) Distributor plate not grounded properly.	Check ground lead wire and terminals.
(g) Defective coil.	Test coil. Replace if necessary.
2. Fuel system faulty.	
(a) Partially closed choke plates.	Check and readjust choke control.
(b) Defective fuel pump.	Test fuel pump. Replace if necessary.
(c) Dirt in main jet.	Clean carburetor.
(d) Accelerating pump inoperative.	Repair or replace.
(e) Float level too low.	Check float level and reset if necessary.
3. Engine compression low..	Refer to "Loss of Compression".

Continued on next page

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
EXCESSIVE DETONATION (PING)	
1. Low octane fuel.	Use a good grade of gasoline.
2. Ignition system faulty.	
(a) Fouled spark plugs.	Clean and regap plugs. Replace if necessary.
(b) Spark advanced too far.	Check and adjust timing.
(c) Point gap incorrect.	Check and readjust points.
3. Fuel system faulty.	
(a) Float level set too low.	Check float level and adjust if necessary.
(b) Main metering system too lean.	Correct as necessary.
4. Engine overheated.	Refer to "Engine Overheated".
5. Cylinder head not bolted down tight.	Tighten cylinder head bolts to specified torque following correct bolt tightening sequence.
ENGINE DOES NOT OPERATE SMOOTHLY	
1. Pitted distributor points.	Clean and readjust points. Replace if necessary.
2. Cracked distributor cap.	Replace cap.
3. Worn or bent distributor shaft.	Replace shaft and shaft bushing.
4. Worn breaker plate hub.	Replace breaker plate assembly.
5. Worn distributor cam.	Replace distributor shaft assembly.
6. Improper point spring tension.	Adjust spring tension or replace points.
7. Leak in vacuum advance diaphragm or connections.	Replace diaphragm. Check all connections.
8. Carburetor float level too high.	Check float level and reset if necessary.
9. Fuel mixture too rich.	Adjust fuel mixture.
ENGINE DOES NOT DEVELOP FULL POWER	
1. Intake air restricted.	Clean air cleaner. Check for restrictions.
2. Exhaust system restricted.	Remove restriction.
3. Ignition system faulty.	
(a) Ignition timing incorrect.	Check and adjust timing.

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
ENGINE DOES NOT DEVELOP FULL POWER - Continued	
3. Ignition system faulty - Continued	
(b) Spark plugs fouled or worn.	Clean and regap plugs. Replace if necessary.
(c) Point gap incorrect.	Check and readjust points.
(d) Distributor advance mechanism not operating	Repair as necessary. Replace worn or damaged parts.
(e) Defective coil.	Test coil. Replace if necessary.
4. Fuel system faulty.	
(a) Fuel pump defective.	Test fuel pump. Replace if necessary.
(b) Throttle linkage restricted, worn or out of adjustment.	Check linkage. Repair as needed.
(c) Choke plate partially closed.	Check choke control linkage. Readjust if necessary.
(d) Float level set too low.	Check float level and reset if necessary.
(e) Accelerating pump inoperative.	Repair or replace.
(f) Power or economizer valve inoperative.	Replace.
5. Air leaks around intake manifold.	Check manifold gasket. Tighten manifold bolts to specified torque.
6. Incorrect valve timing.	Check valve timing.
7. Engine compression low.	Refer to "Loss of Compression".
LOSS OF OIL PRESSURE	
1. Low oil level.	Add oil to correct level.
2. Clogged oil filter element.	Change filter element.
3. Oil pressure indicator defective.	Repair or replace as needed.
4. Oil leaks.	Check for leaks and connect as needed.
5. Oil pump screen clogged.	Clean pump screen and oil pan.
6. Oil pressure relief valve sticking or broken relief valve spring.	Clean valve or replace spring.
7. Oil pump worn.	Repair or replace.
8. Worn main connecting rod or camshaft bearings.	Replace worn bearings.

Continued on next page

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
EXCESSIVE OIL CONSUMPTION	
1. Oil leaks.	Check for leaks and correct as needed.
2. Incorrect grade of lubricating oil.	Use grade of oil specified in "Operator's Manual".
3. Engine overheated.	Refer to "Engine Overheated".
4. Excessive oil in crankcase.	Drain to correct level.
5. Stuck oil control rings, worn valve guides, pistons, rings and cylinder walls.	Replace worn parts. Rebore cylinder block if necessary.
LOSS OF COMPRESSION	
1. Valves sticking.	Clean valve guides and stems. Replace worn parts.
2. Valve mechanism parts worn or broken.	Replace worn or damaged parts.
3. Cylinder head not bolted down tight.	Tighten cylinder head bolts to specified torque following correct bolt tightening sequence.
4. Damaged cylinder head gasket.	Replace gasket.
5. Worn or damaged pistons, rings and cylinder walls.	Replace worn parts. Rebore cylinder block if necessary.
ENGINE OVERHEATED	
1. Coolant level low.	Add coolant to correct level. Check for cause of coolant loss.
(a) Radiator cap loose or missing.	Tighten or replace cap.
(b) Leaks in cooling system.	Correct as necessary.
(c) Leaking cylinder head gaskets or cracked head or cylinder block.	Replace cylinder head gasket. Check for cracks. Replace head or block if necessary.
2. Engine overloaded.	Reduce load on engine. Use lower gear.
3. Dirt and trash on outside of radiator.	Clean radiator fins with air or water pressure.
4. Fan belt slipping.	Check belt tension and adjust if necessary.
5. Cooling system clogged.	Drain and flush cooling system.
6. Thermostats inoperative.	Replace thermostats.
7. Water pump defective.	Repair or replace.
8. Low oil pressure.	Refer to "Loss of Oil Pressure".
EXCESSIVE FUEL CONSUMPTION	
1. Air cleaner restricted or air cleaner oil level too high.	Service air cleaner.

441

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
EXCESSIVE FUEL CONSUMPTION - Continued	
2. Leaks in fuel system.	Check for leaks. Repair as needed.
3. Ignition system faulty.	
(a) Spark plugs fouled or worn.	Clean and regap plugs. Replace if necessary.
(b) Ignition timing incorrect.	Check and adjust timing.
(c) Point gap incorrect.	Check and readjust points.
(d) Low voltage to spark plugs caused by defective coil.	Test coil. Replace if necessary.
4. Fuel system faulty.	
(a) Fuel pump pressure too high.	Check fuel pump. Replace if necessary.
(b) Choke plate partially closed.	Check choke control linkage. Readjust if necessary.
(c) Leaking needle valve.	Replace needle valve and seat.
(d) Float level too high.	Check float level and reset if necessary.
SMOKY EXHAUST	
1. Engine overloaded.	Reduce load on engine. Use lower gear.
2. Air intake restricted or air cleaner oil level too high.	Service air cleaner. Check for restriction.
3. Ignition timing incorrect.	Check and adjust timing.
4. Incorrect grade of lubricating oil.	Use grade of oil specified in Operator's Manual.
5. Fuel mixture too rich.	Adjust fuel mixture.
6. Defective fuel pump.	Check fuel pump. Replace if necessary.
7. Engine compression low.	Refer to "Loss of Compression".
8. Stuck oil control rings; worn valve guides, pistons, rings and cylinder walls.	Replace worn parts. Rebore cylinder block if necessary.
ENGINE NOISES	
1. A sharp rap at idle speed indicates a loose piston pin. The pin at fault can be found by shorting out the spark plugs one at a time. The noise will disappear when the cylinder with the faulty pin is shorted out.	Replace piston pin.

Continued on next page

TROUBLE SHOOTING (Continued)

PROBABLE CAUSE	REMEDY
ENGINE NOISES (Continued)	
2. A flat slap, when advancing engine speed under load, indicates a loose piston.	Replace piston and rebore cylinder block if necessary.
3. A metallic knock when idling or retarding engine speed, which disappears under load indicates worn or loose connecting rod bearings. The bearing at fault can be found by shorting out the spark plugs one at a time. The noise will disappear when the cylinder with the faulty bearing is shorted out.	Replace worn bearings. Check for crankshaft journals for wear.

CRANKCASE VENTILATION SYSTEM
(Closed Type)

The ventilation system consists of a ventilation valve, a hose and fittings connecting the vent opening in the tappet cover to the intake manifold and a hose from the air cleaner to the cylinder head cover. A sealed oil filter cap is used with the ventilation system. The function of the valve is to regulate the flow of crankcase ventilation at various throttle positions.

The ventilation system will operate effectively as long as normal maintenance is applied. Due to the nature of the materials carried by the ventilation system, the valve and piping are subject to fouling with sludge and carbon formations. The ventilation system should be cleaned periodically and at the time of engine overhaul.

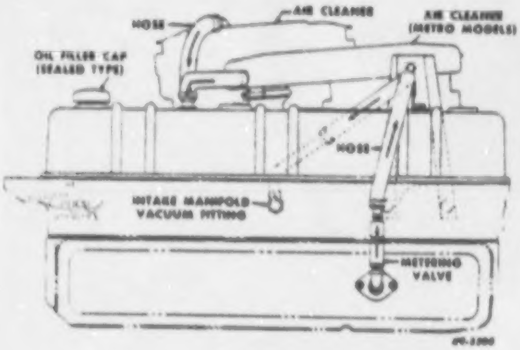

Fig. 122 Crankcase Ventilation System

Service Instructions

Every 10,000 miles or 300 hrs. or less (depending upon operating conditions) the metering valve, hoses and fittings should be removed from the engine, disassembled and thoroughly cleaned.

NOTE: Under cold weather operating conditions when vehicles are operated at slow speeds with low engine temperatures, more rapid accumulations of harmful fumes may be present in the engine. Under these conditions of operation, the valve and tube must be cleaned more frequently than specified above. However, no specific mileage recommendation can be made under these conditions. Frequency of cleaning must be dictated by experience.

Disassemble the valve (Fig. 123) and clean the valve parts with any good solvent cleaner and blow dry with compressed air.

When reassembling the valve parts, be sure to attach the spring on the valve by pushing the end coil over the tapered end of the valve, over the ridge and into the groove machined just under the head of the valve. This is very important. Unless the spring is properly assembled, the valve will not contact the valve seat squarely and will not close properly. Consequently, the engine will not idle properly due to the entrance of too much air into the intake manifold. If the spring has been stretched, the same trouble may occur. Free length of the spring is approximately 9/16 inch. If improper action of the spring is suspected due to spring being distorted, bent or etched from corrosive action, the valve assembly should be replaced.

Inspect oil filler cap and gasket for sealing. If necessary, replace gasket as ventilating system efficiency depends on a sealed cap. Inspect for and correct any air leaks at valve rocker arm cover gaskets, tappet cover gaskets and ventilator hoses and fittings to prevent entry of dirt-laden air.

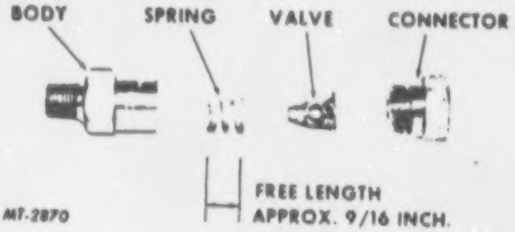

Fig. 123 Exploded View of Ventilation Valve.

PREPARE THE MAN

WORKSHEET
3ABR47232-WB-202

8-9

Technical Training

General Purpose Vehicle Mechanic

ENGINE DISASSEMBLY, ENGINE COMPONENTS INSPECTION AND PARTS SERVICING, ENGINE REASSEMBLY, OPERATION AND VALVE ADJUSTMENT

19 February 1976

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
3340th Technical Training Group
Chanute Air Force Base, Illinois

Designed For ATC Course Use

DO NOT USE ON THE JOB

Vehicle Maintenance Branch
Chanute AFB, Illinois

3ABR47232-WS-202

ENGINE DISASSEMBLY, ENGINE COMPONENTS INSPECTION AND PARTS SERVICING, ENGINE REASSEMBLY, OPERATION AND VALVE ADJUSTMENT

OBJECTIVES

When you have completed the exercises in this worksheet, you will be able to:

1. Remove, inspect, service and reinstall engine components.

2. Perform valve adjustments.

3. Perform required adjustments for satisfactory engine performance.

EQUIPMENT

	Basis of Issue
Engine Trainers	1/2 students
Mechanics Handtools	1/student
Special Tools	1/student
Measuring Tools	1/student
Spring Testers	1/6 students
Timing Lights	1/2 students
Vacuum Pressure Gauge	1/2 students
Engine Tachometer	1/2 students
Compression Gauge	1/2 students
Rod Alignment Testers	1/6 students

PROCEDURE

Note: As each item is completed check it off in the space provided.

Exercise 1

_____1. Disconnect the battery. (Some of the lab engines have a disconnect switch.)

_____2. Drain engine oil. (Use proper container. Replace oil drain plug.)

_____3. Drain engine cooling system, including cylinder block drain plug.

Supersedes 3ABR47330-WS-202, 17 November 1971.
OPR: TWS
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TWS - 400; TTVGC - 1

_____4. Remove exhaust pipe and muffler. (Ask your team mate for help.)

_____5. Remove air cleaner.

_____6. Disconnect:

  _____a. Choke wire from carburetor.

  _____b. Throttle rod from throttle linkage.

  _____c. Vacuum line from carburetor.

  _____d. Fuel line at the fuel filter.

  _____e. Water temperature bulb or wire lead.

  _____f. Primary ignition wires at coil and distributor.

  _____g. Bypass cooling hose at water pump.

  _____h. Upper radiator hose at cylinder head.

_____7. Remove:

  _____a. Intake and exhaust manifold assembly, with carburetor attached.

  _____b. Distributor assembly.

  _____c. Ignition coil.

  _____d. Rocker arm cover and gasket, being careful to preserve the gasket.

  _____e. Valve side cover and gasket, being careful to preserve the gasket.

  _____f. Rock arm assembly. (It's two pieces - be careful.)

  _____g. Push rods and lifters (keep them inorder.)

  _____h. Head bolts. (Use a hinge handle and socket.)

  _____i. Cylinder head and gasket.

  _____j. Oil pan and gasket, preserving gasket if possible.

Note: During actual field operations, all gaskets would be replaced.

_____8. Inspect cylinder walls for ridges above the top of ring travel.

Note: In a normal shop operation, the ridge would be removed each time, since the disassembly would be infrequent. On lab engines there is very short operating time between classes, so the ridge would probably not be noticeable. If there is a ridge, consult the instructor for the proper tools and procedure for removal.

_____9. Removal of piston and connecting rod assemblies:

_____a. Install handcrank wrench on the engine crankshaft pulley.

Note: Do not turn engine by the fan.

_____b. Turn crankshaft until any pair of connecting rod journals are at BDC.

_____c. Remove the nuts securing the bearing cap to the connecting rod, and carefully push the piston out the top of the cylinder wall, first removing the bearing insert and setting it aside.

_____d. Assemble the inserts and bearing cap with the connecting rod, and tighten the bearing cap nuts finger tight.

_____e. Wipe off excess oil from the assembly, and place it on the parts rack.

_____10. Remove all carbon deposits from the cylinder head, using a putty knife and carbon scraper; take care not to damage the head.

Exercise 2

_____1. Upon completion of engine disassembly, consult your instructor and he will help you visually inspect your engine and its component parts.

_____2. After your visual inspection is completed your instructor will assign you to a test engine and assist you while you perform all the inspection measurements described in your student text, number 202.

Exercise 3

_____1. Engine assembly (pistons, connecting rods, and bearings.)

_____a. Lubricate piston cylinder wall, crankshaft and bearing with engine oil.

_____b. Remove bearing cap from connecting rod. (Be careful of bearing inserts.)

_____c. Position ring end-gaps at least 90° apart.

_____d. Install ring compressor on piston.

_____e. Start piston in cylinder bore, after making sure that proper crankshaft journal is at BDC, and that piston is positioned correctly.

_____f. Place a block of wood on the piston and tap it with light hammer blows until the piston is to the bottom of its travel.

_____g. Install bearing cap and bearing and tighten to specified torque.

_____h. Repeat above procedure for all other piston and rod assemblies.

_____2. Engine assembly (crankcase)

_____a. Inspect oil pump strainer and oil pan for foreign matter. If dirty, clean.

_____b. Install oil pan and gasket and tighten.

_____3. Engine assembly (cylinder head, push rods and lifters, and rocker-arms.)

_____a. Install headgasket (make sure it's right side up.)

_____b. Install head alignment pins.

_____c. Install cylinder head.

_____d. Install lifters and push rods in the same holes from which removed.

_____e. Install rocker arm assembly.

_____f. Remove alignment pins and install head bolts.

_____g. Loosen adjustment screws on rocker arms.

_____h. Tighten headbolts in proper sequence, to the specified torque wrench back to its lowest setting.

_____4. Engine assembly (intake and exhaust manifolds, etc.)

_____a. Install intake and exhaust manifold assembly and gaskets.

_____b. Tighten manifold bolts to specified torque.

_____c. Install side cover and gasket.

_____d. Install exhaust pipe and muffler assembly.

_____e. Connect throttle linkage.

_____f. Connect choke wire.

_____g. Install air cleaner and fuel line from pump to carburetor.

_____5. Engine assembly (cooling system.)

_____a. Install hoses.

_____b. Install or connect temperature gauge sending unit.

_____c. Fill system with coolant and check for leaks.

_____d. Fill crankcase to specified level.

_____6. Cold valve adjustment

_____a. Turn engine with handcrank until both valves on #1 cylinder are CLOSED (companion cylinder valves in overlap.)

_____b. Adjust valves according to specifications.

_____c. Adjust valves on remaining cylinders according to firing order, (1, 5, 3, 6, 2, 4) spotting the engine by the valve overlap method.

_____7. Engine assembly (ignition system)

_____a. Turn engine with handcrank until number 1 cylinder begins its compression stroke.

_____b. Continue turning until timing marks line up.

_____c. Install distributor with rotor pointing at the number 1 spark plug contact in the distributor cap.

_____d. Move distributor housing until points start to open, lock in place.

_____e. Install spark plugs.

_____f. Install distributor cap and high tension spark plug wires.

_____g. Install ignition coil and coil secondary wire.

_____h. Connect primary wiring to coil and from coil to distributor.

_____i. Connect vacuum spark-advance line to distributor.

_____8. Prestart check

_____a. Check coolant and oil level.

_____b. Check all electrical and fuel connections.

_____c. Remove all tools from trainer.

_____d. Close choke.

_____e. Open throttle slightly.

Note: Do not open throttle very far, or your engine will overspeed and damage and injury may result.

_____9. Start engines

_____a. Turn ignition switch "ON."

_____b. Depress starter button.

_____c. Do not crank engine for more than 30 seconds. If it does not start wait at least 2 minutes before repeating.

____10. Initial engine checks

_____a. As soon as engine starts, check oil pressure. If no oil pressure develops, STOP ENGINE IMMEDIATELY and call instructor.

_____b. Check ammeter to see if generator is charging.

_____c. Set throttle for a fast idle, choke open, and allow engine to reach normal operating temperature.

_____d. During warmup, inspect engine for fuel, oil, and coolant leaks.

____11. Hot valve adjustment

_____a. Reduce engine speed to a slow idle.

_____b. Locate specifications in the appropriate shot manual.

_____c. Call your instructor and he will show you how to perform the hot valve adjustment.

_____d. When finished stop engine.

_____e. Install valve cover and gasket.

____12. Final ignition timing

_____a. Call your instructor for a demonstration of a tack-dwell unit and a timing light.

_____b. When finished stop engine.

_____c. Remove, clean, and store test equipment.

Note: Make sure tach-dwell unit is shut off.

____13. Compression test (dry)

____a. Engine must be normalized and battery must be fully charged.

____b. Remove all spark plugs and air cleaner.

____c. Ground the secondary lead from the coil.

____d. Open throttle valve.

____e. Open choke valve.

____f. Install remote starter switch.

____g. Insert compression gauge into spark plug hole and crank engine for at least four compression strokes.

____h. Record reading on chart below.

____i. Repeat steps g and h for cylinders

1	2	3	4	5	6

____14. Compression test (wet)

____a. Squirt about 1 tablespoon of oil in each cylinder.

____b. Repeat steps 13g and 13h.

1	2	3	4	5	6

____c. Reassemble removed parts with the exception of the secondary coil lead.

____15. Cranking vacuum test

____a. Back out throttle stop screw so throttle plates are tightly closed.

____b. Install a vacuum gauge as close to the center of the intake manifold as possible.

_____c. Block off all other vacuum openings in the intake manifold.

_____d. Crank engine and observe vacuum reading.

_____e. Record reading below.

____

_____f. Compare these test results with compression test results and diagnose any mechanical problems in the engine. (Record your diagnosis below.)

____

____

____

____

____

____

_____g. Reassemble all removed parts.

_____16. Carburetor adjustment

_____a. Install tach-dwell and turn meter to low RPM range.

_____b. Start engine and allow it to stabilize.

_____c. Adjust idle mixture screw until the highest reading possible is attained.

_____d. Adjust idle speed screw until engine idles at 500 rpm.

_____e. Remove all test equipment, clean, and return to its storage place.

_____f. Clean and store tools.

_____g. Clean engine trainer and report to instructor.

452

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47232-1-PT-301
3ABR47231A-PT-301
3ABR47231B-PT-301
3ABR47231C-PT-301
3ABR47~~230-~~PT-204C
232

Technical Training

Special Vehicle Repairman
(Towing and Servicing Vehicles)
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)
General Purpose Vehicle Mechanic

8-9

SOLDERING, TUBE CUTTING, BENDING, AND FLARING

10 November 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47231-PT-301, 3ABR47230-PT-204C, 6 February 1971.
OPR: TDWS
DISTRIBUTION: X
TDWS - 800; TTOC - 6

Designed For ATC Course Use
Do Not Use on the Job.

OBJECTIVES

1. Given a soldering gun or iron, a piece of wire and solder, you will be able to:

   a. Prepare the soldering gun or iron for soldering.

   b. Prepare the wire to be soldered.

   c. Solder a wire connection. Acceptable performance will be to the satisfaction of your instructor.

2. Given a piece of tubing and the necessary tools, you will be able to cut, flare and bend the tubing. Acceptable performance will be to the satisfaction of the instructor.

PROCEDURE

Obtain the materials and tools you will need to complete this lesson from your instructor.

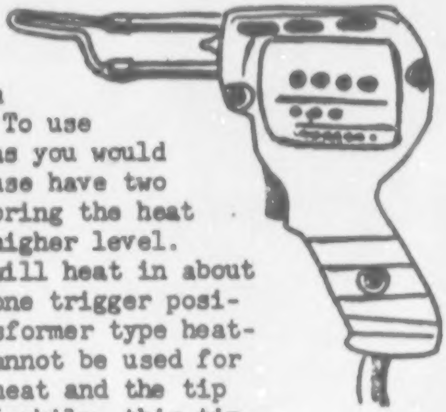
Do the work as directed by the program, working through the program as you would a regular text.

Each of the frames bordered by question marks has a group of statements from which you are to select the correct answer. You may underline or circle the letter representing your answer. On the last page of this text is printed the correct answers. Any time you are in doubt as to the correctness of your choice, make your choice first, then refer to the last page for confirmation.

PRECAUTIONARY NOTES

The following precautions should be observed while performing the soldering and tubing tasks:

1. Remove all rings, watches, and other jewelry before operating any equipment.
2. An electric soldering iron should not be left connected for long periods of time. This not only wastes electric current but it may destroy the heating element.
3. Do not throw an electric soldering copper into the toolbox with your other tools. The point of the iron or the cord could be damaged.
4. Do not solder a gasoline container with an electric solder-iron because a short circuit of the cord could ignite the fumes.
5. Burned electric wires can cause short circuits so keep the electric cord away from the heated parts of the iron.
6. Hold articles to be soldered with pliers or clamps as metal transfers heat quickly and can cause serious burns if the items are held in the hand.
7. Don't tighten the hand screw on a tube cutter too tightly or the tubing may be crushed or split.
8. Use caution when bending stainless steel tubing as the tubing may break or the tube bender may be damaged.
9. Be sure to place all of the fittings necessary on the tubing before the ends the tubing are flared.



A soldering gun is often used when the soldering job is not too large. To use this gun, pull back on the trigger, as you would with a pistol. Many of the guns in use have two trigger positions -- the first will bring the heat up to one level and the second to a higher level. When the trigger is pulled, the gun will heat in about three seconds. Some guns have only one trigger position. The soldering gun uses a transformer type heating element. It heats quickly but cannot be used for long periods of time or it will overheat and the tip will be burned and become useless. Luckily, this tip can be replaced.

QUESTION 1.

? ?

? Which of these statements is correct? ?

? a. All soldering guns have two positions of the trigger which cause heating. ?

? b. Soldering guns take a long time to heat. ?

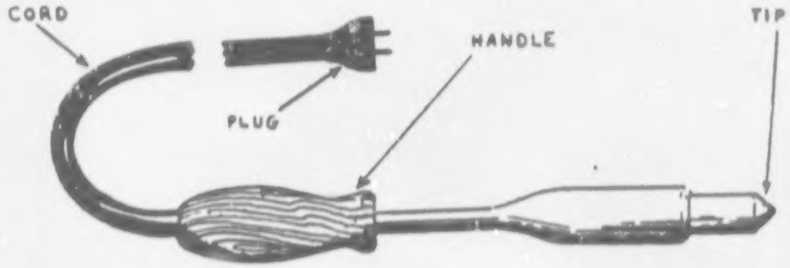
? c. Soldering guns cannot be used for long periods of soldering. ?

? d. The tips for soldering guns cannot be replaced if they become damaged. ?

? ?

Select a soldering gun from those tools with which you have been provided and take it to your work area.

1. Connect the gun to the proper electrical outlet.
2. Pull the trigger to the first position. Allow it to heat.
3. Pull the trigger to the second position and allow the tip to reach its top heat.
4. Release the trigger and disconnect the gun.



If the soldering job is too large for a gun or if no guns are available, you will probably use an electric soldering iron.

The complete preparation of an iron for soldering would include heating, annealing, filing, and tinning of the tip.

If the soldering iron will not heat properly, it should be annealed. This is done by heating the tip with a blow torch to a cherry red color and immediately plunging the tip into cold water. This procedure softens the copper tip and allows more heat to be transferred to the work.

An iron does not need to be annealed very often, in fact you may never have to anneal an iron. Information is provided in the procedure step at the top of the next frame to direct you if the operation is required.

Frame 4.

⇩

If you should ever need to anneal an iron, follow this procedure:

1. Heat the tip with a torch or outside heat source to a cherry red color.
2. Plunge the tip into cold water. This softens the copper tip.

QUESTION 2.

? ?

? How is a soldering iron tip annealed? ?

? a. The tip is filed to a sharp point. ?

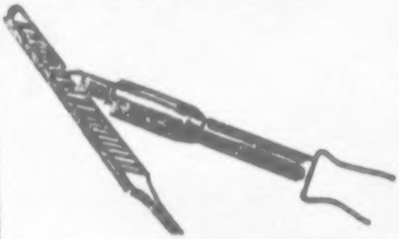
? b. The tip is heated to a cherry red color and then plunged into cold water. ?

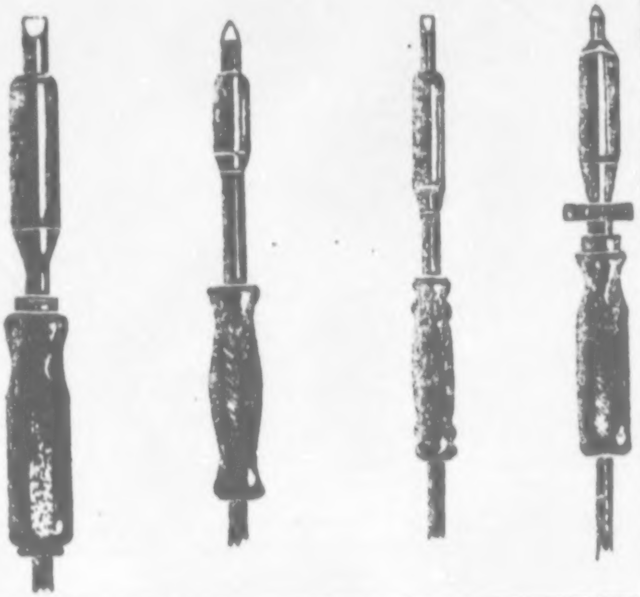
? c. A new tip is installed to replace the old tip. ?

? d. Every condition is corrected so that nothing will ever have to be done to the soldering iron. ?

? ?

After the tip is annealed, it should be smoothed by filing. Use a fine file to give a flat, smooth surface for tinning. Do not change the shape of the tip. Use light strokes while filing. Smooth each face of the tip, and complete by polishing with fine sandpaper.





QUESTION 3.

? ?

? After the tip of a soldering iron is annealed, it should ?

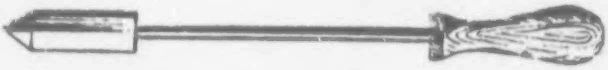
? a. be used immediately to see if the solder sticks to it. ?

? b. be replaced if it shows any rough spots. ?

? c. laid to one side to permit it to season. ?

? d. smoothed with a fine file and then with sandpaper. ?

? ?



A plain soldering iron or copper is used where there is no electric outlet available or when it is not dangerous to use a flame-producing heat source. An iron of this type is heated in a gas furnace or by a blowtorch. Condition the tip of the soldering iron as you would the tip of an electric soldering iron.

No one can teach you to know when a soldering iron has reached the correct temperature. Only experience can teach you this, but you can test an iron by applying solder to the tip. When the iron is too hot, the solder will sputter and spread too quickly whereas if the iron is too cold, the solder will not flow readily.

QUESTIONS 5 and 6.

? ?

? 5. You can tell if a soldering iron has reached the proper temperature by ?

?
a. watching the color of the tip. ?

? b. dripping water on the tip. ?

? c. applying solder to the iron. ?

? d. having your instructor show you the things to look for. ?

? 6. A soldering iron is tinned to ?

? a. provide for better heat transfer.

b. provide for better solder transfer. ?

?
c. provide for neater appearing work. ?

? d. make the work of soldering much easier. ?

? ?

Frame 8.

Regardless of the type of soldering device you use, a neat job should result. The solder must have melted quickly, dlowed into and around the union, and then forzen into place without including air bubbles, oxides, carbon particles, or other foreign materials. Any impurities weaken a joint and build up the electrical resistance of the joint.

The soldering iron or its teip must be designed to give up its heat rapidly and to channel this heat directly into the working area. Remember, heat rises, so hold the iron under the work to be soldered not over it. If at all possible, let the solder soak in.

Material to be soldered must be cleaned as carefully as the soldering iron. Cleanliness is of the utmost importance. If possible, soldering should be done in an area that is reasonably clean and free from excessive dust. Draft areas should be avoided so that the soldering iron will not cool.

Parts contaminated with dirt, oil, grime, grease, etc., cannot be soldered successfully. "Bright - clean" these parts mechanically by cleaning with a cloth or brush which has been dipped in alcohol or in some other approved cleaning solvent.

Badly corroded parts may be cleaned with fine abrasive paper, a wire brush, or by scraping with a pocket knife.

QUESTION 7.

? ?

? Material to be soldered must be cleaned because ?

? a. they will look much better on a completed job. ?

? b. dirty material cannot be soldered successfully. ?

? c. the part to be soldered can be seen more easily. ?

? ?

Many parts which have been thoroughly cleaned should be pre-tinned before being joined together. To pre-tin a cleaned part, a thin layer of solder is applied to the cleaned part. This keeps the part clean and requires only a small amount of additional solder to complete the soldering job.

It works out well to pre-tin the ends of wires which are to be attached to a receptacle or a plug. Pre-tinning may be done with a soldering iron if there are only a few wires.

If there are a large number of wires to be tinned, it may be worth while to use a soldering pot. Solder may be placed in a soldering pot and kept heated to a pre-determined temperature. Instead of pre-tinning each wire or connection with an iron, dip several in the pot at one time and save time.

QUESTION 8.

? ?

? The advantage of using a soldering pot to pre-tin wires and other material is that ?

a. the pre-tinning will be uniform.

b. it saves solder.

c. it saves much time.

d. a better job of pre-tinning will be accomplished.

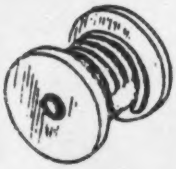
? ?

Frame 10.

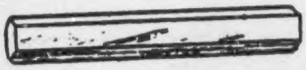
Solder is a mixture of tin and lead. There are as many kinds of solder as there are tin and lead combinations. More tin added makes the solder harder but it will crystallize and break easily, while solder with more lead than tin will be soft but not very strong.

Soft solder is the type used for wire splicing, radiator repairs, and jobs requiring small amounts of solder. Soft solder is often made in plain (solid wire form), or it may be hollow enclosing a core of acid or rosin.

Hard solder, often called "brazing solder," is a silver alloy which is used when greater mechanical strength or exposure to higher temperatures is required. Hard solder includes a certain percentage of copper.



SPOOL SOLDER



BAR SOLDER

PREPARE THE MAN

PROGRAMMED TEXT 3ABR47~~330~~232-PT-204D
3ABR47231-1-PT-304A
3ABR47231A-PT-304A
3ABR47231B-PT-304A
3ABR47231C-PT-304A

Technical Training

Automotive Repairman
Special Vehicle Repairman
(Towing and Servicing Vehicles)
(Crash Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)

VEHICLE STORAGE, CLIMATIC TECHNIQUES AND CORROSION CONTROL

30 November 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes Programmed Text 3ABR47330-PT-204D, 3 November 1970.
OPR: TDWS
DISTRIBUTION: X
TDWS - ~~800~~ 150, TTOC - 6

Designed For ATC Course Use

Do Not Use on the Job.

464

FOREWORD

This programmed text was developed for use in 3ABR47330, Automotive Repairman Course.

OBJECTIVES

Upon completion of this programmed text the student will be able to explain:

1. The servicing of Air Force vehicles operating in various climates.
2. The storage of Air Force vehicles.
3. The shipment of Air Force vehicles.
4. Corrosion Control of Air Force vehicles.

An accuracy of 70% must be attained on the criterion test which measures the text.

INSTRUCTIONS

Note:

1. Read each bit of information carefully. Answer the question(s) after each bit of information. Record your answers in the appropriate space on the answer sheet given to you. In some cases you are required to match a series of questions with at least three (3) alternatives. In such cases, consider the alternatives as part of each question and select your answers
2. If you have any questions, ask your instructor.

The United States Air Force is different from any commercial or civilian concern you have ever had contact with. Where civilian businesses are concerned with servicing your vehicle for local usage, the Air Force is concerned with world-wide operations. As a result, the Air Force mechanics are generally more versatile in their servicing procedures than are their civilian counterparts.

In the next few frames of this lesson we will be discussing the types of servicing required for vehicles operating in various climates. Primarily, we will be concerned with climates where the temperatures reach 32°F. or below. Consequently, the title of this sub-sequence will be "Winterization."

As you know, when the temperatures are below 32°F. water will freeze, oil flows slower, and moving parts that have been lubricated are harder to operate.

QUESTION 1.

? ?

? Vehicles operating in temperatures below 32°F. require ?

? a. different servicing than vehicles operating in temperatures above 32°F. ?

? b. the same servicing as vehicles operating in temperatures above 32°F. ?

? c. no special servicing. ?

? d. special servicing of the lubricated parts only. ?

? ?

Frame 2. Answer: 1. a

Primarily, the purpose of winterizing a vehicle is to insure the safety of that vehicle. Of course, satisfactory operation of the vehicle would not be obtained if the vehicle wasn't winterized. Failure to winterize a vehicle could result in added expense to the Air Force and possible damage to the vehicle. Keep in mind that we are discussing areas where the temperature is 32°F or lower.

QUESTION 2.

? ?

? What does "winterization" mean? ?

? a. The vehicle has been serviced to operate in moderately cool temperatures. ?

? b. The vehicle is equipped and serviced to operate in extremely cold temperatures only. ?

? ?

? c. The vehicle has been serviced to perform safely and satisfactorily in extremely cold temperatures. ?

? d. The vehicle cannot operate under extremely cold temperatures. ?

? ?

QUESTION 3.

? ?

? Any vehicle that has been serviced to operate in temperatures below 32°F. (extremely cold temperatures) has been ?

? a. cold treated. ?

? b. winterized. ?

? c. cold weather serviced. ?

? d. climatized. ?

? ?

It is virtually impossible to memorize all of the procedures necessary to accomplish all the servicing required on Air Force vehicles. The most important thing to remember is, "If you don't know, consult the appropriate Technical Order."

Although winterization means that a vehicle has been serviced so as to operate safely and satisfactorily in extremely cold temperatures. it must be noted that varying degrees of cold climates dictate varying degrees of winterization. For example: If a vehicle is to be operated in temperatures varying from 32°F. to 15°F. it is safe to assume that the winterization process would differ from that for a vehicle being operated in temperatures constantly below -30°F. Technical Order 36-1-7 explains specifically how a vehicle will be winterized in order to meet certain climatic conditions.

Frame 4.

T.O. 36-1-7 explains the four types of winterization. Vehicles are serviced for Type "A" winterization when the temperature ranges from -10°F to -65°F when pre-heater facilities are available. Because pre-heater facilities are available, Type " " winterization is considered to be "normal."

QUESTION 4.

Which of the following areas require Type "A" winterization?

a. Extremely cold and do not have pre-heater facilities.
b. Extremely cold but do not need pre-heater facilities.
c. Extremely cold and have pre-heater facilities.
d. Not below freezing but have pre-heater facilities.

QUESTION 5.

Which type of winterization is performed on vehicles operating in temperatures ranging from -10°F. to -65°F. where pre-heater facilities are available?

a. Type "A" winterization.
b. Type "B" winterization.
c. Type "C" winterization.
d. No winterization.

Answers: 4. c .5. a

Frame 5.

According to T.O. 36-1-7, Type "B" winterization is similar to Type "A" except that Type "B" is conducted in areas that do not have pre-heater facilities. For example: Those vehicles which operate on an ice cap where there are no electrical facilities would have to be given Type "B" winterization. This type of winterization is called "abnormal."

QUESTION 6.

? ?

? What is Type "B" winterization? ?

a. Servicing a vehicle to operate safely and satisfactorily in temperatures ranging from -10°F. to -65°F. where there are no pre-heater facilities.

b. Servicing a vehicle to operate safely and satisfactorily in temperatures above 32°F.

c. Servicing vehicles to operate safely and satisfactorily in areas where the temperature range is from -10°F. to -65°F. where pre-heater facilities are available.

d. Servicing vehicles to operate in areas so they will not freeze when the vehicle pre-heater is used.

? ?

QUESTION 7.

? ?

? What type of winterization is given to a vehicle that is to operate in a temperature range of -10°F. to -65°F. where no electrical or pre-heater facilities are available? ?

a. Type "A" (normal).

b. Type "B" (normal).

c. Type "B" (abnormal).

? ?

Frame 6. Answers: 6. a 7. c.

Still another type of winterization explained in T.O. 36-1-7 is known as "partial" winterization. Partial winterization is Type "C" and is used generally for areas that are warmer than are Types "A" and "B". The temperatures for Type "C" winterization range from 32°F. to -10°F. Therefore, Type "C" winterization is for areas with temperatures different than for Types "A" and "B".

QUESTION 8.

? ?

? Which range of temperatures are for Type "C" winterization? ?

? a. 65°F. to 32°F. ?

b. 32°F. to -65°F.

? c. 32°F. to -10°F. ?

? d. -10°F. to -65°F. ?

? ?

QUESTION 9.

? ?

? Vehicles which are required to operate in temperatures ranging from ?
32°F. to -10°F. will be given which of the following types of
? winterization? ?

? a. Type "B". ?

? b. Type "C". ?

c. Type "A".

? d. No winterization. ?

? ?

Answers: 8. c 9. b

QUESTIONS 10 through 12.

? ?

For each question select either a, b, or c for the correct answer.

10. "Abnormal" because no pre-heater facilities are available and the temperature is from -10°F. to -65°F.

11. "Normal" because pre-heater facilities are available and the temperature range is from -10°F. to -65°F.

12. "Partial" because the temperature ranges from 32°F. to -10°F.

a. Type "A" winterization.

b. Type "B" winterization.

c. Type "C" winterization.

? ?

The fourth and last type of winterization we will discuss is Type "D". This winterization process does not involve any special servicing. It is used for materials handling equipment which is to be used inside a heated building at all times. Electric and hydraulic forklifts are among the types of equipment which require this type of winterization.

Frame 8. Answers: 10. b 11. a 12. c

QUESTION 13.

? ?

? For what type of vehicles is Type "D" winterization designed? ?

? a. Vehicles which are to be used outside only. ?

? b. Vehicles which are to be used inside mostly but occasionally are used outside. ?

? c. Vehicles used inside only and which do not require special servicing. ?

? d. Vehicles which are not affected by cold temperatures. ?

? ?

? ?

QUESTION 14.

? ?

? What type of winterization is required for vehicles that are to be used inside heated buildings at all times? This type of winterization does not require special servicing. ?

? a. Type "B" winterization. ?

? b. Type "C" winterization. ?

? c. Type "A" winterization. ?

? d. Type "D" winterization. ?

? ?

Answers: 13. c 14. d

Winterization of a vehicle includes servicing the cooling system with a solution to prevent its freezing. Ethylene glycol is the type of anti-freeze generally used by the Air Force. When Types "A" and "B" winterization is performed, the cooling system will be filled with a pre-mixed solution that doesn't require water. This mixture is an arctic compound that is specified in T.O. 36-1-7.

QUESTION 15.

? ?

? What type anti-freeze is used for Types "A" and "B" winterization? ?

? a. Ethylene glycol. ?

? b. Alcohol ?

? c. Arctic compound requiring water. ?

? d. Arctic compound that does not require water. ?

? ?

In arctic areas where the temperature ranges from -10°F. to -65°F. it is extremely difficult to have an anti-freeze which contains water. When operating vehicles in these temperature ranges, a pre-mixed solution is used.

Frame 10. Answer: 15. d

QUESTION 16.

? ?

? Pre-mixed solutions of anti-freeze is used for which type(s) of winterization? ?

?

- a. Type "D".
- b. Types "A" and "B".
- c. Type "C".

? ?

On types of winterization other than Types "A" and "B", ethylene glycol may be added to the vehicle's cooling system. When ethylene glycol is used, no other anti-freeze solution may be added. Mixtures of ethylene glycol and alcohol are not permitted.

QUESTION 17.

? ?

? What is the acceptable solution for Type "C" winterization? ?

- a. Alcohol and water.
- b. Alcohol and ethylene glycol.
- c. Alcohol without water.
- d. Ethylene glycol and water.

? ?

Answers: 16. a 17. d

QUESTION 18.

? ?

? When may alcohol and ethylene glycol be mixed? ?

? a. Never. ?

? b. Anytime. ?

? c. On special occasions. ?

? d. In mild temperatures. ?

? ?

QUESTION 19.

? ?

? Ethylene glycol and water is an anti-freeze solution used for which ?
type of winterization?

? ?

a. Type "C".

? ?

b. Type "D".

? ?

c. Type "A".

? ?

d. Type "B".

? ?

? ?

Frame 12. Answers: 18. a 19. a

In any type of vehicle winterization, the cooling system should be protected to a level that would prevent it from freezing. If you are located in an area where the lowest expected temperature is -40°F. the cooling system should be protected to at least -50°F. If the lowest expected temperature is to be 32°F. then the cooling system should be protected to 22°F.

QUESTION 20.

? ?

? Using the information given above, select the correct statement. ?

? a. Cooling systems should be protected to at least 50 degrees below the expected low temperature. ?

? b. Cooling system should be protected to at least 40 degrees below the expected low temperature. ?

? c. Cooling system should be protected to at least 10 degrees above the lowest expected temperature. ?

? d. Cooling system should be protected to at least 10 degrees below the lowest expected temperature. ?

? ?

Answer: 20. d

In a cold climate, all vehicles should be winterized and have their radiators protected with anti-freeze.

QUESTION 21.

? ?

? The protection for a vehicle's cooling system should be ?

? a. 10° below the expected low temperature. ?

? b. 20° below the expected low temperature. ?

? c. 30° below the expected low temperature. ?

? d. 40° below the expected low temperature. ?

? ?

Now that you are familiar with the term "winterization," let's move on to another very important aspect of vehicle servicing, "The Storage and Shipment of Vehicles."

Frame 14. Answer: 21. a

The United States Air Force and other governmental agencies have a tremendous supply of vehicles. At any given time there may be more vehicles available at a given base than are needed. Therefore, it becomes necessary to store these excess vehicles for future use. All such stored vehicles must be protected to guard against rust, corrosion, pilferage, and other such losses.

QUESTION 22.

? ?

? A logical thing to say, then, would be that ?

? a. vehicles are stored so as to prevent deterioration. ?

? b. vehicles are stored so as to cause deterioration. ?

? c. vehicles cannot be stored. ?

? d. the Air Force has too many vehicles available. ?

? ?

QUESTION 23.

? ?

? When vehicles are stored for possible future use, these vehicles must be protected against ?

? ?

a. outside air.

? ?

b. inside heat and humidity.

? ?

c. rust, corrosion, and pilferage.

? ?

d. nothing.

? ?

? ?

Answers: 22. a 23. c

QUESTION 24.

? ?

? Vehicles are protected against rust, corrosion, and pilferage when they are to be ?

? ?

a. winterized.

? ?

b. protected.

? ?

c. overhauled.

? ?

d. stored.

? ?

? ?

There are three levels of storage for government-owned vehicles. Level "A" is accomplished on vehicles to be stored in excess of 90 days.

QUESTION 25.

? ?

? Of the types of storage used on government vehicles, the one that affords protection for 90 days or more is called ?

? ?

a. Level "B".

? ?

b. Level "C".

? ?

c. Level "A".

? ?

d. Level "D".

? ?

? ?

Frame 16. Answers: 24. d 25. c

QUESTION 26.

? ?

? If you process a government vehicle for storage to guard against ?
rust, corrosion, and pilferage and you give the vehicle Level "A"
? processing, the vehicle is then protected for ?

? a. 90 days. or more. ?

? b. 90 days or less. ?

? c. indefinite periods. ?

? d. immediate use. ?

? ?

QUESTION 27.

? ?

? Select the correct statement from those listed below: ?

? a. Level "A" storage protects vehicles for 90 days or less while ?
in storage.
? ?
b. Level "A" storage protects stored vehicles for an indefinite
? period. ?

? c. Level "A" storage protects stored vehicles for 90 days or ?
more.
? ?
d. Level "A" storage does not protect stored vehicles.
? ?

? ?

Answers: 26. a 27. c

Frame 17.

Occasionally it is necessary to store a vehicle for less than 90 days. This storage is known as Level "B" storage. Although it is for a shorter period, these vehicles must also be treated so that they are protected against rust, corrosion, and pilferage.

QUESTION 28.

? ?

? Level "B" storage is for vehicles stored for ?

? a. 90 days or more. ?

? b. 90 days or less. ?

? c. indefinite periods. ?

? d. immediate use. ?

? ?

QUESTION 29.

? ?

? When a vehicle is to be protected against rust, corrosion, and pilferage for storage periods not to exceed 90 days, it is given ?

? ?

a. Level "A" storage.

? ?

b. Level "B" storage.

? ?

c. no storage.

? ?

d. no protection.

? ?

? ?

Frame 18. Answers: 28. b 29. b

QUESTION 30.

? ?

? A correct statement about vehicle storage is that, ?

? a. Level "A" storage is used for storing vehicles for 90 days or less. ?

? b. Level "B" storage is used for storing vehicles for 90 days or more. ?

? c. Levels "A" and "B" are not terms associated with vehicle storage. ?

? d. Level "B" storage is used for storing vehicles for 90 days or less. ?

? ?

If you found it necessary to store a vehicle for an extremely short period of time you would process this vehicle for Level "C" storage. This type of storage might only involve removing the battery from the vehicle until the vehicle is ready to be used. Storage facilities and time is very limited on this type of storage.

QUESTION 31.

? ?

? "Limited" storage is called ?

? a. Level "A" storage. ?

? b. Level "B" storage. ?

? c. Level "C" storage. ?

? d. Level "D" storage. ?

? ?

Answers: 30. d 31. c

QUESTION 32.

? ?

? Suppose you, as the mechanic, find it necessary to order a part for ?
a vehicle which you are repairing. It will take approximately four
? (4) days for this part to arrive. You must process this vehicle for ?
storage. What level of storage will you perform?
? ?
a. Level "B".
? b. Level "C". ?
c. Level "A". ?
? d. Level "D".
? ?

? ?

QUESTION 33.

? ?

? The reason you would process the vehicle described in the preceding?
frame for Level "C" storage is because Level "C" storage is for
? ?
a. 90 days or less.
? b. 90 days or more. ?
? c. all vehicles. ?
? d. "limited" service or storage. ?

? ?

QUESTION 34.

? ?

? Any vehicle which can be driven away on short notice, or one that ?
is deadlined waiting for parts, is stored in
? ?
a. Level "C" storage.
? b. Level "A" storage. ?
? c. Level "B" storage. ?
d. any level storage.
? ?

? ?

Frame 20. Answers: 32. b 33. d 34. a.

QUESTIONS 35 through 37.

? ?

? Let's see if you remember all of the different levels of storage. Match the right column below with the left column. ?

? ?

_____ 35. Level "A" storage. a. 90 days or less.

? ?

? _____ 36. Level "B" storage. b. 90 days or more. ?

c. Limited storage.

? _____ 37. Level "C" storage. ?

? ?

Because there are so many different service items to perform in preparing a vehicle for storage it is virtually impossible to remember them all. The important thing to remember is that the Air Force has a Technical Order which gives a step-by-step breakdown of the servicing required. Always be sure to consult the appropriate technical order before attempting to store a vehicle.

Level "A" stored vehicles are subject to periodic inspections to determine their condition. Every 90 days, all Level "A" stored vehicles will have an inspector walk by and take a look at them to determine if any physical damage exists.

Answers: 35. b 36. a 37. c Frame 21.

QUESTION 38.

? ?

? This inspection of Level "A" stored vehicles is called a ?

? a. visual inspection. ?

? b. complete inspection. ?

? c. partial inspection.

? d. drive-away inspection. ?

? ?

QUESTION 39.

? ?

? Visual inspections are conducted every 90 days on Level "A" stored vehicles to determine ?

? ?

a. physical condition.

? b. internal condition. ?

? c. engine condition. ?

? d. all of the above. ?

? ?

QUESTION 40.

? ?

? Inspections that determine the general physical condition of Level "A" stored vehicles are called ?

? ?

a. physical conditioning and are conducted every 90 days.

? b. complete inspections and are conducted every 90 days. ?

? c. internal inspections and are conducted every 90 days. ?

? d. visual inspections and are conducted every 90 days. ?

? ?

Frame 22.

Answers: 38. a 39. a 40. [illegible]

Every 6 months (180 days) 1% of the Level "A" stored vehicles will be taken out of storage and put into running condition to determine if they function properly.

QUESTION 41.

? ?

? This type of inspection is called a ?

? a. functional inspection. ?

? b. partial inspection. ?

? c. visual inspection. ?

? d. physical inspection. ?

? ?

At the end of the 180 days, if the 1% of the inspected vehicles function properly, they are re-processed for Level "A" storage and left until the next 180-day cycle when another 1% will be functionally inspected.

487

QUESTION 42.

? ?

? Select the statement below which is correct: ?

? a. Level "A" stored vehicles are functionally inspected every three months. ?

? b. 1% of the Level "A" stored vehicles are visually inspected every 90 days. ?

? c. 1% of the Level "A" stored vehicles are functionally inspected every 180 days. ?

? d. All Level "A" stored vehicles are functionally inspected every 180 days. ?

? ?

QUESTION 43.

? ?

? A functional inspection of stored vehicles means that the vehicles will be ?

? a. looked at carefully. ?

? b. restored to a running condition. ?

? c . overhauled. ?

? d. left alone for 180 days. ?

? ?

QUESTION 44.

? ?

? 1% of Level "A" stored vehicles will be functionally inspected every ?

? a. 90 days. ?

? b. 60 days. ?

? c. 180 days. ?

? d. 30 days. ?

? ?

Frame 24. Answers: 42. c 43. b 44. c

When available, buildings are used to store vehicles. Vehicles may be stored outside when inside storage areas are not avilable. Where a vehicle is stored depends on the existing requirements.

QUESTION 45.

? ?

? Vehicles may be stored ?

? a. inside only. ?

? b. outside only. ?

? c. mostly inside. ?

? d. inside or outside. ?

? ?

Answer: 45. d

When vehicles are stored outside they are subjected to all the natural weather elements. This means, of course, that the bodies and hulls will collect water, snow, and other forms of moisture. One end of the vehicles must be raised slightly to allow collections of water and moisture to drain out.

QUESTION 46.

? ?

? Vehicles, then, that are stowed outside will have ?

? a. both ends jacked up level. ?

? b. neither end elevated. ?

? c. one side elevated. ?

? d. one end elevated. ?

? ?

Frame 26. Answer: 46. d

If vehicles are stored outside on natural terrain, the area must shed water rapidly and remain fairly solid under all weather conditions. As a fire safety precaution, all grass and weeds will be kept to a minimum in the storage area.

QUESTION 47.

? ?

? Select the correct statement: ?

? a. Vehicles may be stored on soft ground but the grass and weeds must be cut. ?

? ?

b. Vehicles may be stored outside on soft ground as long as the ? terrain has good drainage. ?

? c. Vehicles should be stored on solid soil with good drainage, ? and weeds and grass will be kept to a minimum in the area to ? prevent a fire hazard. ?

? d. Vehicles should be stored on hard ground with good drainage. ? but weeds and grass should be permitted to grow as tall as ? they will. ?

? ?

Most vehicles can be safely stored outside. However, some vehicles should be stored inside. Vehicles such as fire trucks, vehicles containing electronic equipment, and fork lifts are among those that should be stored inside. If it is necessary to store these types of vehicles outside they will be afforded protection equal to inside storage.

QUESTION 48.

? ?

? Select the correct statement: ?

? a. Vehicles such as fire trucks, forklifts, and vehicles containing electronic equipment should never be stored inside. ?

? ?

? b. Vehicles such as fire trucks, forklifts, and vehicles with electronic equipment must be stored inside. ?

? c. Vehicles such as forklifts, fire trucks, and vehicles with electronic equipment should be stored inside but they may be stored outside if equal protection is taken to protect them from the weather. ?

? ?

? d. Vehicles such as fire trucks, forklifts, and vehicles with electronic equipment cannot be stored, either inside or outside. ?

? ?

? ?

Frame 28. Answer: 48. c

We know that anything stored inside a building has better protection than when it is stored outside. The same is true for vehicles. When inside storage areas are available, they should be used first. This applies to all types of vehicles to be stored. As was just discussed in the previous frame, consideration for inside storage should be given to special type vehicles first.

QUESTION 49.

? ?

? A true statement is: ?

? a. All vehicles should be stored inside when possible. ?

? b. All vehicles should be stored outside. ?

? c. Vehicles should never be stored inside. ?

? d. Vehicles should never be stored outside. ?

? ?

Answer: 49. a

Frame 29.

Corrosion control includes all steps necessary to prevent/retard corrosion (rust) on Air Force vehicles. It will be performed on vehicles being processed for overseas shipment, vehicles going into storage, and, as necessary operational vehicles. Particular interest will be shown to the underside and interior surfaces of the vehicles, as a vehicle normally rusts from the inside out. The outside surface must also be inspected and serviced.

QUESTION 50.

? ?

? Which of the following statements best describes corrosion control? ?

? a. Corrosion control is performed only in the Air Force. ?

? b. Corrosion control is rust control of Air Force vehicles. ?

? c. Commercial vehicles always have adequate corrosion treatment before delivery. ?

? ?

? d. Corrosion control is not important because it effects only the vehicle body. ?

? ?

QUESTION 51.

? ?

? Which of the following vehicles are not normally processed for corrosion ? control?

? ?

a. Vehicle being shipped.

? ?

b. Operational vehicles as necessary.

? ?

c. Vehicles being processed for storage.

? ?

d. All vehicles on a yearly basis.

? ?

? ?

Frame 30. Answers: 50. b 51. d

Corrosion control will include cleaning and preparing vehicle surfaces for coating and the application of applicable preservatives. Cleaning and preparing will consist of washing with soap and water, and if necessary the removal of mud, gravel, rust, and other foreign materials with a wire brush, putty knife or sandpaper. Applying preservatives will be in accordance with TO 36-1-52, Preparation and Corrosion Treatment of Vehicles. Some general items include; waxing the exterior surface of the vehicle, do not buff unless necessary for appearance sake; spot painting any bare metal surfaces; undercoating the vehicle.

QUESTION 52.

? ?

? Which of the following preparation steps is always necessary when processing a vehicle for corrosion control? ?

? ?

a. Sanding the vehicle

? ?

b. Brushing the vehicle.

? ?

c. Washing the vehicle.

? ?

d. Scraping the vehicle.

? ?

? ?

Answer: 52. c

Frame 31.

Climatic conditions are the primary consideration for corrosion control. Excessive sand, salt, saline solution, coral dust and high humidity cause abnormal corrosion. Close attention must be maintained in these areas by the vehicle operator and the maintenance man.

QUESTION 53.

? ?

? Under highly corrosive conditions who would be most likely to observe vehicle deterioration? ?

? ?

a. Vehicle operator and motor pool dispatcher.

? ?

b. Motor pool dispatcher and passengers.

? ?

c. Vehicle operator and maintenance control personnel.

? ?

d. Vehicle operator and vehicle maintenance men.

? ?

? ?

Frame 32. Answer: 53. d

There are two types of corrosion control, type "A" and type "B". Type "A" includes complete servicing of all body surfaces, for example; under floor mats, under headlines, inside windshield posts, inside trunks and complete underbody and exterior of the vehicle. Type "B" is complete underbody servicing and a followup to a type "A" servicing.

QUESTION 54.

? ?

? Which of the following would normally be performed on class "B" corrosion treatment? ?

?

a. Undercoat the vehicle underbody.

?

b. Spray the windshield posts.

?

c. Remove the headliner.

?

d. Treat all tires for corrosion.

?

? ?

PREPARE THE MAN

432
PROGRAMMED TEXT 3ABR47~~3~~30-PT-205B
3AAR42173-PT-501
3ABR47231-1-PT-301A
3ABR47231A-PT-301A
3ABR47231B-PT-301A
3ABR47231C-PT-301A

Technical Training

General Purpose Vehicle Repairman
Aerospace Ground Equipment Repair Technician
Special Vehicle Repairman
(Towing and Servicing Vehicles)
(Crash/Fire Vehicles)
(Refueling Vehicles)
(Materials Handling Vehicles)

THE TYPICAL VEHICLE FUEL SYSTEM

10 November 1971

CHANUTE TECHNICAL TRAINING CENTER (ATC)

This supersedes 3ABR47330-PT-205B, 3AAR42173-PT-501, 25 May 1971.
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FOREWORD

This programmed text was prepared for use in 3ABR47330, Automotive Repairman Course. The text was validated in 1964 using 30 students from the course. 90% of the students achieved the objectives as stated. The text has been in use since 1964 and is considered to be valid.

OBJECTIVES

After completing this programmed text, you will be able to:

1. List the components of a typical vehicle fuel system.
2. List the purpose of each component of a vehicle fuel system.

Objectives to be accomplished without error.

This text is also used in 3AAR42173 Course.

August 1969

500

INSTRUCTIONS

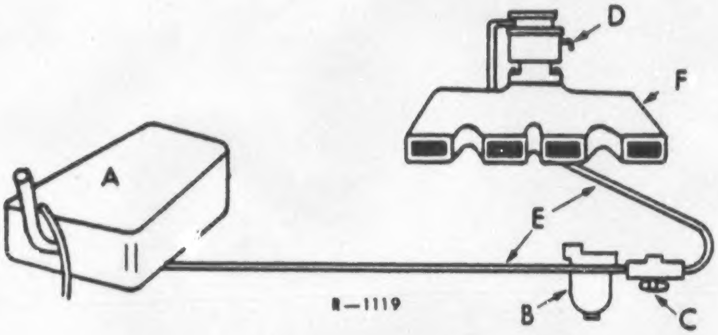
This Programmed Instructional Package, with its answer sheet is designed to be used either as a home-study project or a classroom project. The manner in which you will go through the package is the same in either case. You will place your answers to the questions on a separate piece of paper. The correct answers, or confirmation as it is called, are located at the top of the page following the questions. Since you will be working on your own, it will be possible for you to simply copy the correct answers. If this is your desire, be our guest. However, if a test is given at the completion of this package you would be in a rather embarassing position. The BEST way is to carefully read the material in the information section, read the question and write your answer to the question on a separate piece of paper. Your answers need not be exactly the same as the answers in the confirmation section, but the MEANING must be the same. If you should not have the correct answer to the question then go back to the information section and read it again. It is essential that you understand each bit of information given before you go to the next frame. There is no time limit except that set by the instructor if this package is used as a classroom project. If you should not achieve a high enough score on the test that is given you will be required to "retake" the package until you can achieve a satisfactory score.

Does the information above definitely say that there will be a test given when you complete this package?

Frame 2

NO: But it implies that one MIGHT BE GIVEN.

The fuel system of a vehicle serves two basic functions. The first of these is to store enough fuel to provide an operating range of two or three hundred miles. The second is to move the fuel from the storage tank, clean it, vaporize it and deliver it to the combustion chambers of the engine, in a combustible form. There are variations, but the main units of a vehicle fuel system are the storage tank (A), fuel filter (B), fuel pump (C), carburetor (D), rigid and flexible tubing which connect the units (E) and the intake manifold (F) which delivers the fuel in its final combustible form to the engine cylinders.

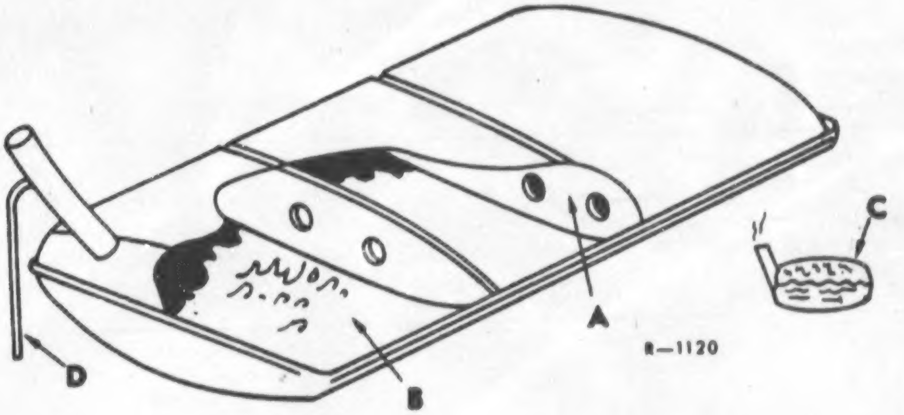


1. Discounting the Intake Manifold and the Carburetor how many units would be left in the typical fuel system?

1. 3 - fuel storage tank, fuel filter, fuel pump. The fuel lines are a means by which the fuel passes from one unit to the other.

The first of the units in the fuel system is the storage tank. The tank may take on a variety of shapes, which may have been dictated by the vehicle or the capacity it is intended to have.

The tank is lead lined to prevent corrosion. (A) Baffles are arranged in the tank in such a manner as to strengthen the structure and prevent the fuel from sloshing during vehicle operation. (B) Sloshing of the fuel would create vapors in the air space above the fuel level in the tank (C), and since fuel is highly volatile, these vapors would escape through the tank vent (D) creating an unnecessary waste. The tank vent serves two purposes in that it serves as an overflow vent for expanding fuel during hot weather and as an air vent. Air passes through the vent into the tank displacing the fuel as it is being used by the engine. Unsatisfactory engine performance could result if this vent should become clogged.



2. Why is the fuel tank lead-coated on the inside?

3. What is the purpose of the baffles inside the tank?

4. What is the purpose of the vent?

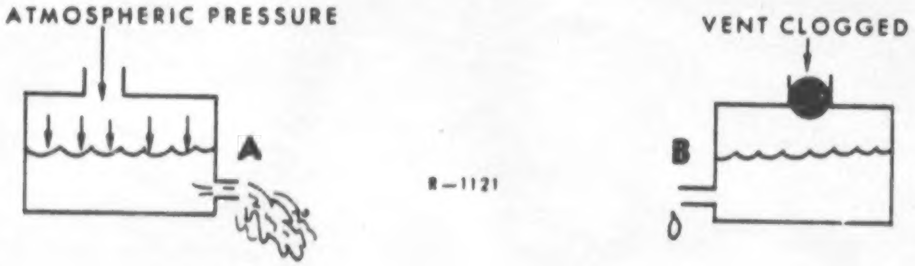
Frame 4

2. Prevent corrosion.
3. Prevent fuel from sloshing and strengthen the structure.
4. Overflow for expanding fuel, and to allow air to enter the tank as fuel is being used.

It was mentioned in the previous frame that a clogged tank vent could cause some problems. Consider, for a moment, the air which is drawn into your lungs when YOU EXPAND THEM. The void you created in your lungs when you expand your lungs is REPLACED by air. If you should close all passages to your lungs you could not draw air into your lungs, and you know what will happen if the situation exists for very long.

Now, what happens when the fuel pump takes in a charge of fuel? It creates a void in the tank in the same manner as expanding lungs. Air must be allowed to replace this void. Otherwise a vacuum will be created in the tank, and the fuel pump is not designed to pull fuel out of a vacuum. In fact the air that is allowed to bleed in through the vent actually PUSHES the fuel from the tank to the fuel pump.

The air that is vented into the tank is at ATMOSPHERIC PRESSURE. As the pump removes a given amount of fuel from the fuel line, atmospheric pressure will force the same amount of fuel to take its place (A). If the vent is clogged, air pressure cannot enter to work on the fuel in the tank. Fuel will not be pushed to the fuel pump and the fuel pump will not be able to deliver fuel to the carburetor in constant and sufficient amount to give satisfactory engine operation (B).



5. What is the force that pushes the fuel from the tank to the fuel pump?

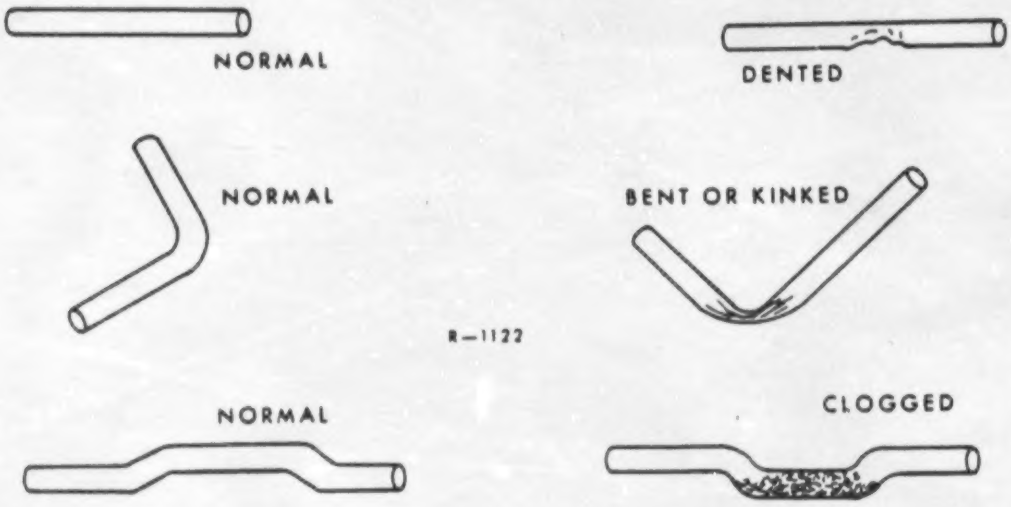
6. What effect does a clogged vent have on fuel flow from the tank?

7. What is one thing to check when looking for trouble in the fuel system?

5. Atmospheric pressure.
6. Serves to prevent (or restrict) fuel flow from the tank.
7. Clogged fuel tank vent.

Rigid and flexible lines (or tubing if you prefer) are used to provide a path through which the fuel can flow from the fuel tank to the other units in the fuel system. Generally the fuel lines are large enough so that dents caused by rocks will not restrict fuel sufficiently to cause trouble. However, severe dents or kinks in the line may restrict fuel flow sufficiently to effect engine performance. (Just like a clogged vent.) Large amounts of foreign material could accumulate in the low spots of the fuel line with the same effect on fuel flow as a dented or kinked line.

COPPER TUBING



R–1122

8. What is the purpose of the fuel lines?

9. When looking for the trouble that might be caused by the fuel system what should you consider, other than a clogged tank vent, as a possible cause of the trouble?

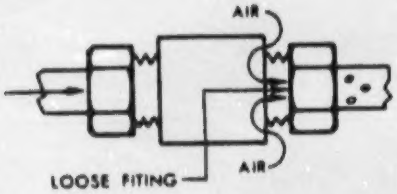
Frame 6

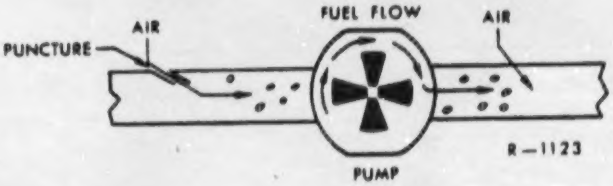
8. Provide a path through which fuel can flow from the fuel tank to other units in the fuel system.

9. Dented, kinked or clogged fuel line.

Before we proceed to the other units in the fuel system let's dwell a little longer on other fuel line troubles.

Remember the effects of atmospheric pressure on the fuel in the tank? It pushes the fuel to the pump but the air never reaches the pump. (Unless the fuel tank is empty.) It is always a good idea to physically check the fuel quantity when trouble in the fuel system is suspected. (Never trust the fuel gage.) Air can enter the fuel line through a loose fitting, a punctured or cracked line or fitting. Usually this problem can readily be discovered by the presence of fuel on or near the loose fitting, puncture or crack.





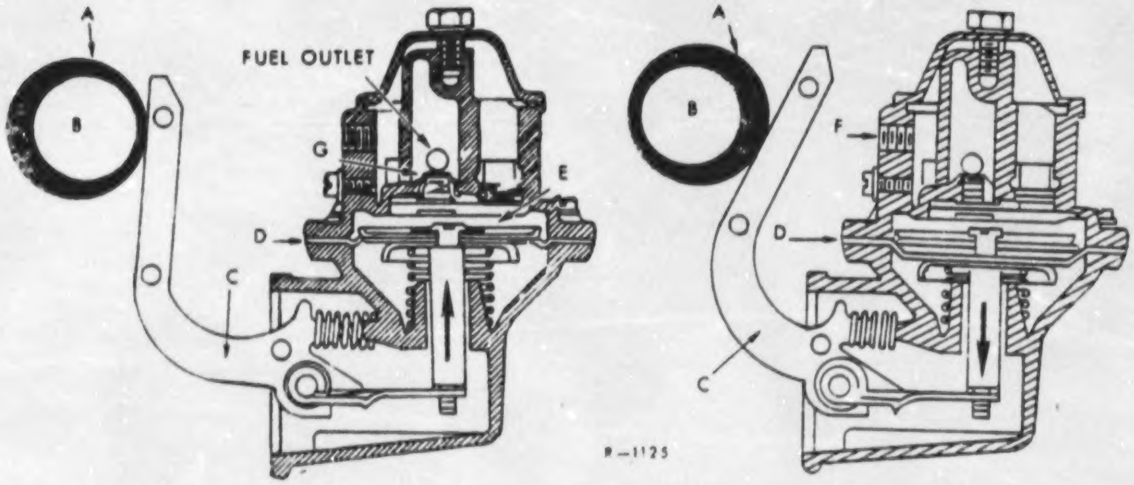
10. While inspecting the fuel system what other possibilities, other than clogged vent, dented, kinked or partially clogged fuel lines, should you inspect?

11. What effect would air in the fuel line have on vehicle operation?

Frame 8

12. Remove foreign particles from the fuel.
13. Clean or replace them.

The next unit in the fuel system to be considered is the fuel pump. Its purpose is to pump fuel to the carburetor. Fuel pumps are of several different designs but are either mechanically or electrically operated. The mechanically operated pump works on the principle of differential pressure. An eccentric (a) on the camshaft (b) moves a lever (c) which is connected to a diaphragm (d) by linkage. As the eccentric rotates, the lever will move first in one direction then the other. This movement in turn, moves the diaphragm. As the diaphragm moves down it creates a lower-than-atmospheric pressure in the chamber (e). Since atmospheric pressure is exerting a force on the fuel in the tank, the fuel will offset the inlet valve (f) and flow into the partial vacuum created by the diaphragm. As the diaphragm is moved upward it exerts pressure on the fuel in the chamber (e). The fuel, under pressure, exerts pressure on the intake valve closing it. At the same time the fuel, under pressure, offsets the exhaust valve (g), and flows out to the next unit in the fuel system. Remember that the fuel on the "outlet" side of the fuel pump is under greater pressure than the fuel entering on the "inlet" side of the pump.



14. What is the purpose of the fuel pump?

15. On what principle of operation does the mechanically operated fuel pump work?

16. What forces push the fuel into the partial vacuum created in the chamber by the downward movement of the diaphragm?

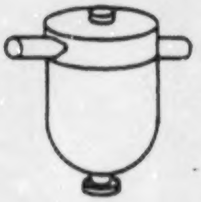
17. What happens to the inlet and outlet valves when the diaphragm is moved upward?

10. Fuel quantity in tank, loose or cracked fittings, punctured or cracked fuel line.

11. Air bubbles will reduce the quantity of fuel reaching the fuel pump which in turn cuts down on the fuel being delivered to the carburetor.

The fuel filter is sometimes a separate unit as illustrated in the figure below (1). Its main purpose is to remove all foreign matter from the fuel before it reaches the pump. Sometimes the filter is an integral part of the fuel pump. (2) Some automobile manufacturers install an additional filter immediately after the fuel pump or in the intake fuel fitting to the carburetor (3). Since some filters are designed to remove water from the fuel in addition to dirt, rust particles and anything else that may find its way into the fuel, it becomes a necessity to clean (4) or replace them periodically.

1



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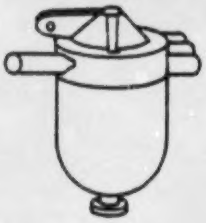

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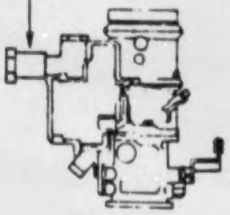

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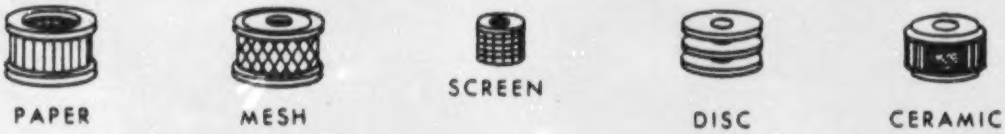


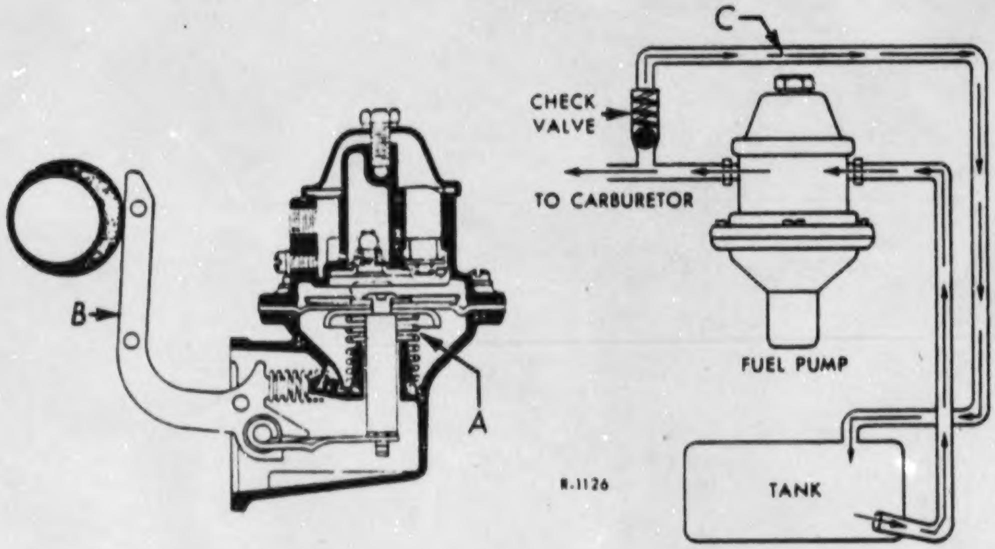
Water was mentioned in the paragraph above. Water enters the fuel by accident, but more likely by condensation. While water settles to the bottom of the filter, lowest parts of fuel lines or fuel tank it still can become a problem especially if it freezes.

12. What is the purpose of the fuel filter?

13. What action should be taken on filters periodically?

14. Pump fuel to the carburetor.
15. Differential pressure.
16. Atmospheric pressure working on the fuel in the fuel tank.
17. The intake valve is closed and the exhaust valve is opened.

In a later lesson you will learn that the carburetor will not accept all the fuel the pump sends up to it. What happens to this excess fuel? If you will notice the spring under the diaphragm (a) in the illustration below, its main purpose is to return the diaphragm to its origianl position. The only thing the lever does (b) is pull the diaphragm DOWN. If the carburetor will not accept fuel the diaphragm will STAY DOWN. The lever will continue to move. As the fuel is consumed by the vehicle it must be replaced. The spring, under the diaphragm, gradually pushes the fuel out of the chamber to the carburetor. When the diaphragm reaches its original position the action of the lever pulls it down again pulling a charge of fuel in from the tank. Another method of disposing of the excess fuel is to return it to the tank. (c)



18. Does the diaphragm move continually with the action of the lever?

19. What is the purpose of the spring under the diaphragm?

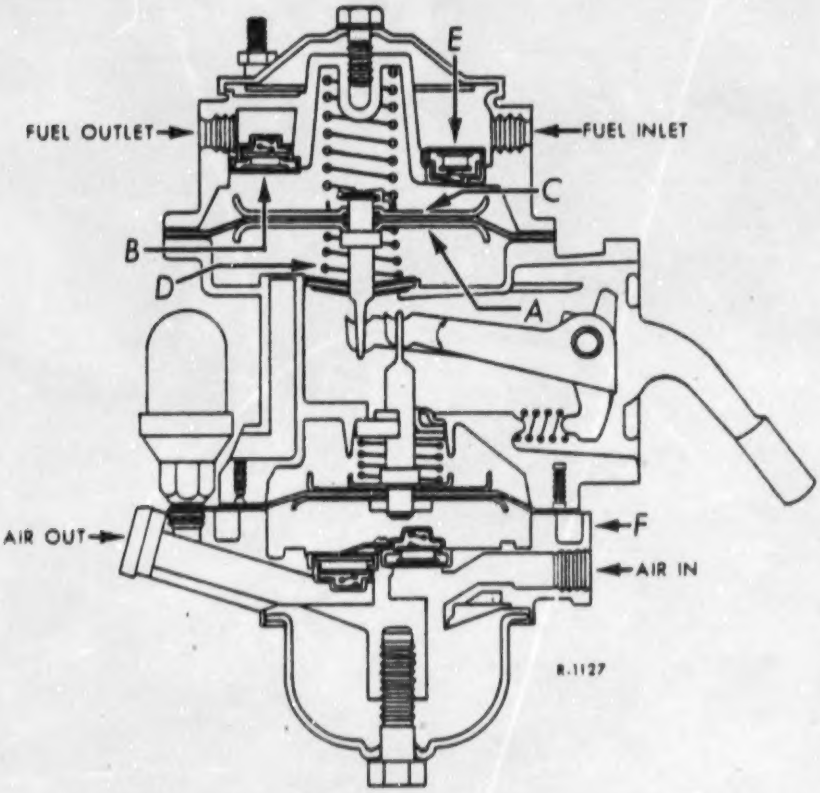
20. How does the spring under the diaphragm affect the fuel flowing to the carburetor?

21. What other method is used to dispose of excess fuel being pumped to the carburetor?

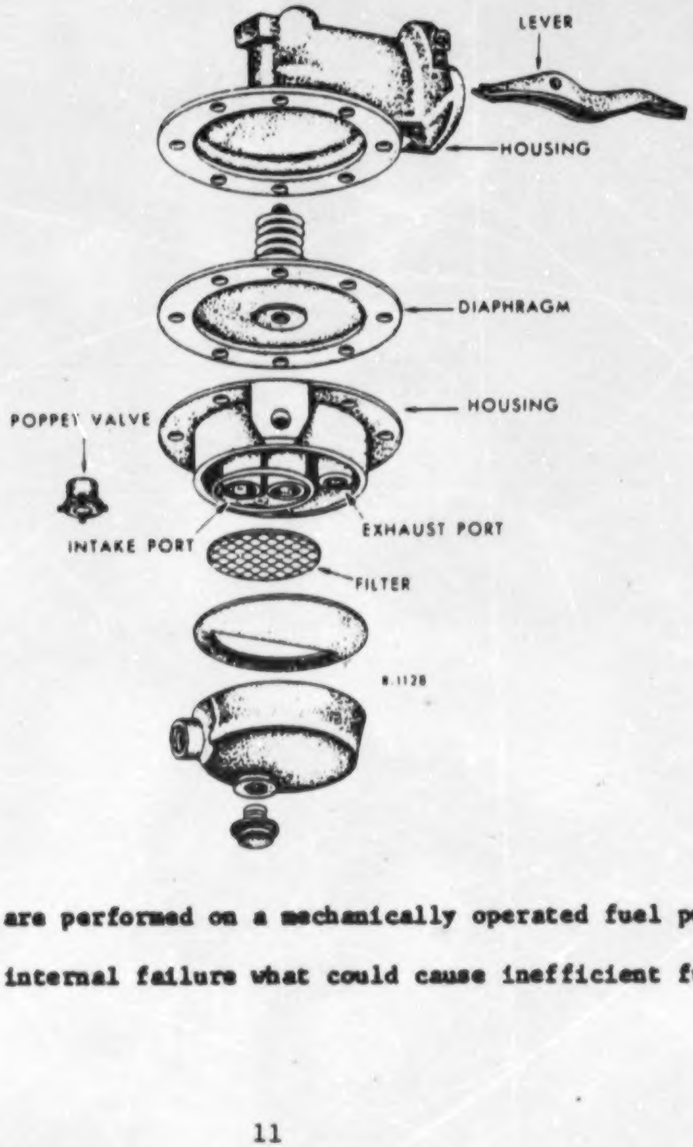
Frame 10

18. No.
19. Return the diaphragm to its original position.
20. It presses against the diaphragm creating a constant pressure on the fuel in the chamber. As the fuel in the carburetor is consumed it is replaced by fuel under pressure from the fuel pump chamber.
21. By-pass the excess fuel back to the bank.

Some vehicles utilize a vacuum booster to increase the efficienty of the windshield wipers and to operate vacuum controls. Since the trend is overwhelmingly toward the use of electric windshield wipers, the vacuum booster will be only mentioned here. Like the pump mentioned on the previous frame, it contains a diaphragm. The action of the diaphragm (a) opens the inlet check valve on the downward stroke, the diaphragm return spring (d) forces the outlet check valve (e) open and moves the fuel out of the chamber toward the carburetor. The operation of the vacuum portion (f) of the pump is identical to the operation of the fuel pump portion. Instead of pumping fuel it pumps air.



Generally a visual inspection of the fuel system will suffice to discover loose fittings, dented or kinked lines and loose or lost screws on the fuel pump itself. Loose screws on the fuel pump are easily discovered since fuel will leak out around them. Loose screws may be enough to cause the fuel pump to lose its efficiency. Failure of internal parts is more frequently the cause for fuel pump malfunctions. The diaphragm may be ruptured, valves may not be operating properly, a broken or weak spring or even a broken lever will cause the pump to be inoperative. A worn eccentric may even cause the fuel pump to be blamed because of its inability to deliver fuel to the carburetor. Tests such as vacuum tests, pressure tests and volume tests are performed to determine a malfunction when the cause is not readily apparent. The illustration below is a "blowup" view of the typical mechanically operated fuel pump. It should be evident that given the internal parts of the pump, repair can easily be affected in the field.



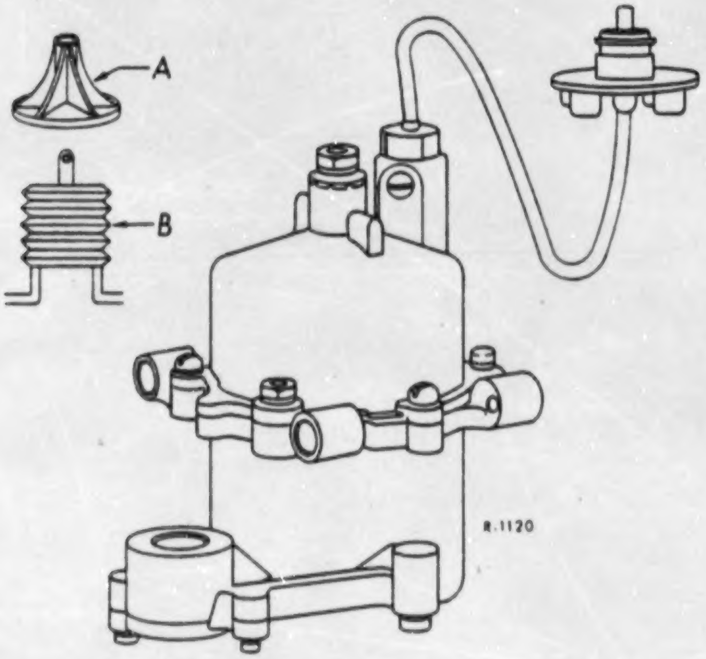
22. What tests are performed on a mechanically operated fuel pump?

23. Other than internal failure what could cause inefficient fuel pump operation?

Frame 12

22. Vacuum, pressure and volume test.
23. Loose screws, worn or broken lever, or a worn eccentric on the camshaft.

Electrical fuel pumps are not in common usage on general purpose Air Force vehicles. Their principal use is as fuel-transfer pumps. They are usually fully submerged in the fuel tank. The driving unit is usually an electric motor driving an impeller (a). Some electric pumps consist of a motor operating a set of bellows (b) which operate much the same manner as the diaphragm mechanical pump. The nature of their construction is such that a defective electric pump will seldom be repaired in the field.

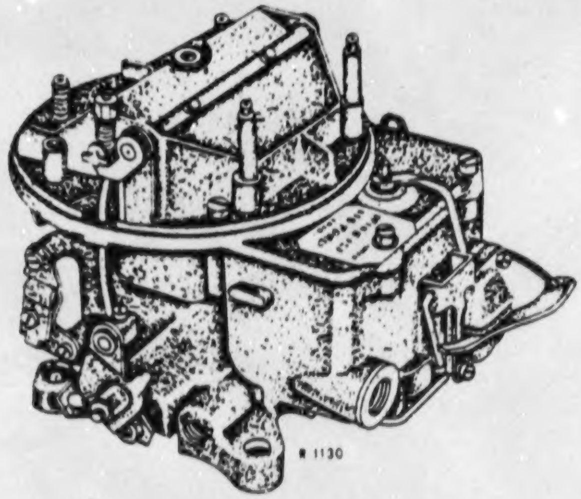


24. How are electric fuel pumps usually mounted?

25. What are the two main types of electrically operated fuel pumps?

24. Inside the tank.
25. Bellows.

The next unit in the fuel system is the carburetor. It may be a one, two, or four barrel carburetor or may be installed in multiples. (More than one carburetor.) Regardless of its size its primary purpose is the same. Before the engine can consume the raw fuel that is in the tank the fuel must be turned into a vapor form or atomized and proper proportions of it mixed with the air drawn into the carburetor. The carburetor must also supply the correct fuel-to-air ratio throughout the full range of engine operation. While the carburetor is probably the most important item in the fuel system it will be discussed in some detail in a later lesson. A typical carburetor is shown below.



26. What is the purpose of the carburetor?

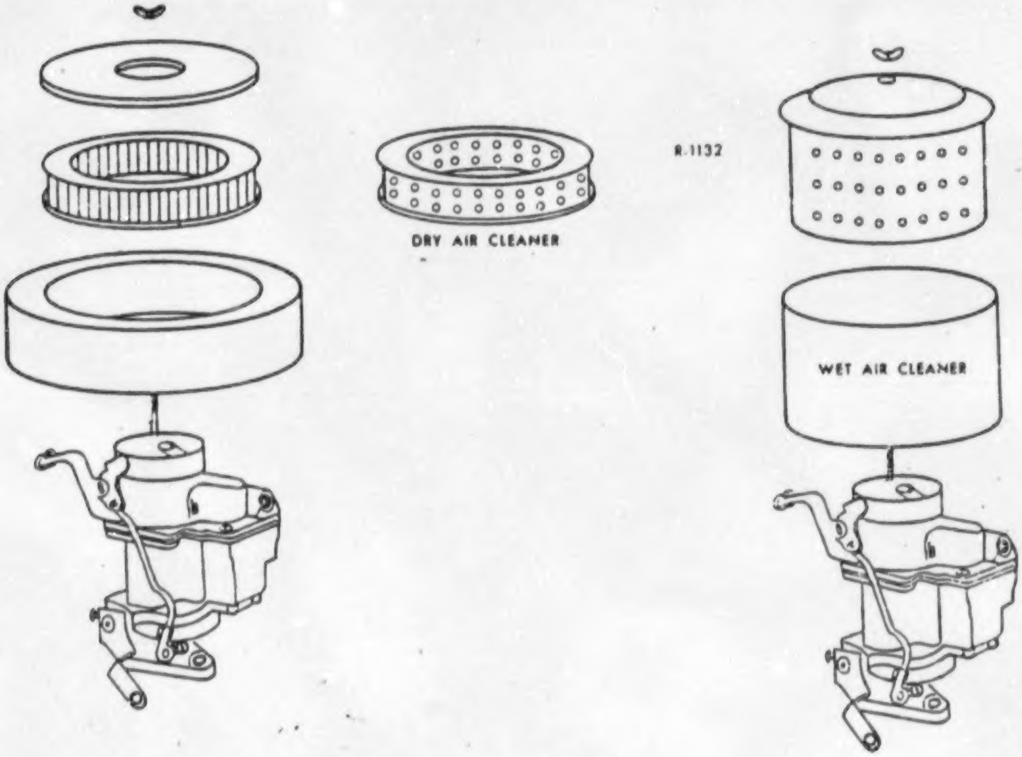
27. Delivered the fuel in vapor form from the carburetor to the cylinders.

28. An unwanted air leak (from disconnected vacuum lines, broken intake gaskets, loose mounting bolts, cracked, warped or punctured manifold).

29. The fuel air mixture is diluted resulting in unsatisfactory engine performance.

30. B.

One other unit, which is not part of the fuel system but is part of the air induction system and thus should be considered at this time is the air cleaner. There are several types of air cleaners, ranging from the copper gauze, or "chore girl" type, to the wet-type or "oil bath" cleaner. The simple, "chore girl" cleaner is cleaned periodically by rinsing the element in clean solvent, soaking it in clean engine oil and re-installing it. The "oil bath" cleaner is washed in solvent, the oil is replaced with clean oil, and it is replaced on the carburetor. The almost universal application on the modern vehicle is the dry-type paper (or fiber) replaceable element cleaner. Regardless of the design, the purpose remains the same, that of preventing dirt from entering the engine. The filtering element is cleaned or replaced because as it becomes clogged with dirt it "chokes off" the supply of air and increases fuel consumption.



31. What is the purpose of the carburetor air filter?

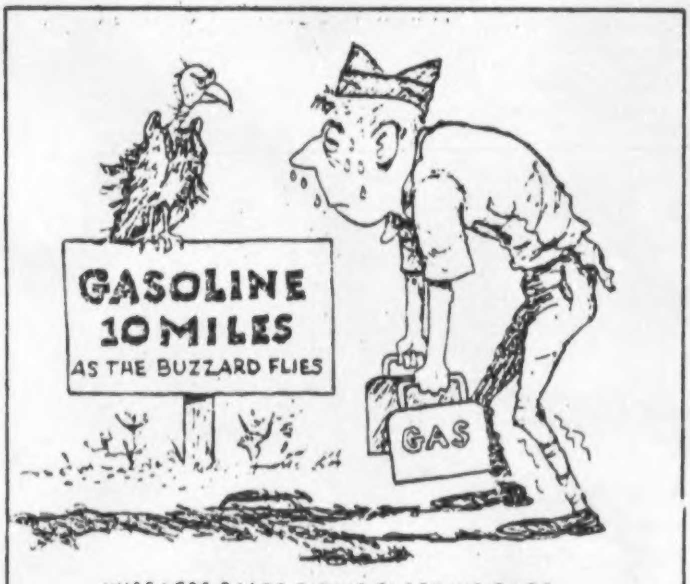
32. What are the two types of air filters?

Frame 16

31. Clean air entering the carburetor.
32. Dry and wet type.

We have covered the fuel system briefly. We know the basic components of the system, their functions, and their locations in the fuel-flow sequence. Each of the units we studied will be discussed in greater detail in the classroom sometime in the next few days. Most of the units will be given you to disassemble and inspect, so that you will become more familiar with them.

If you have completed this program as a home study project, your instructor will test you in the classroom. If you have completed the program in class, review it as necessary at this time and notify your instructor.



WISEACRE PAIGE DIDN'T CHECK HIS GAGE
NOW HE'S OUT IN THE "BOONIES"
WITH THE BUZZARDS AND SAGE.!!